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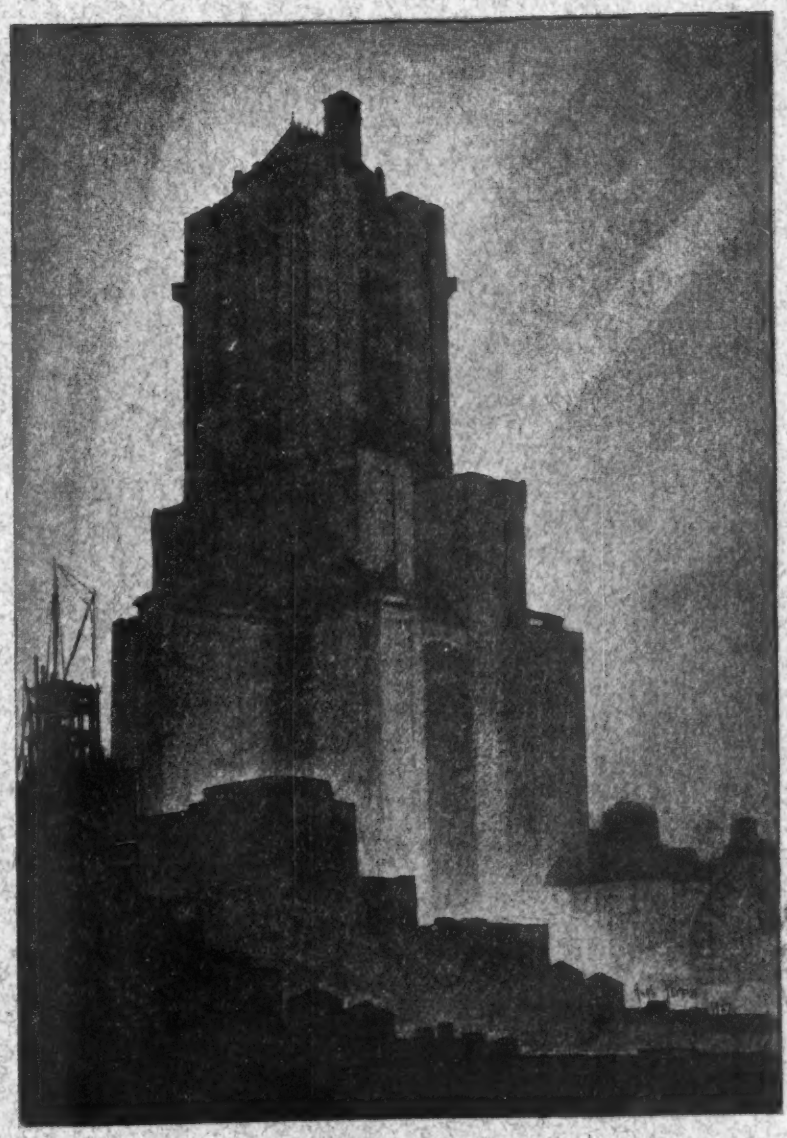

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APRIL, 1927

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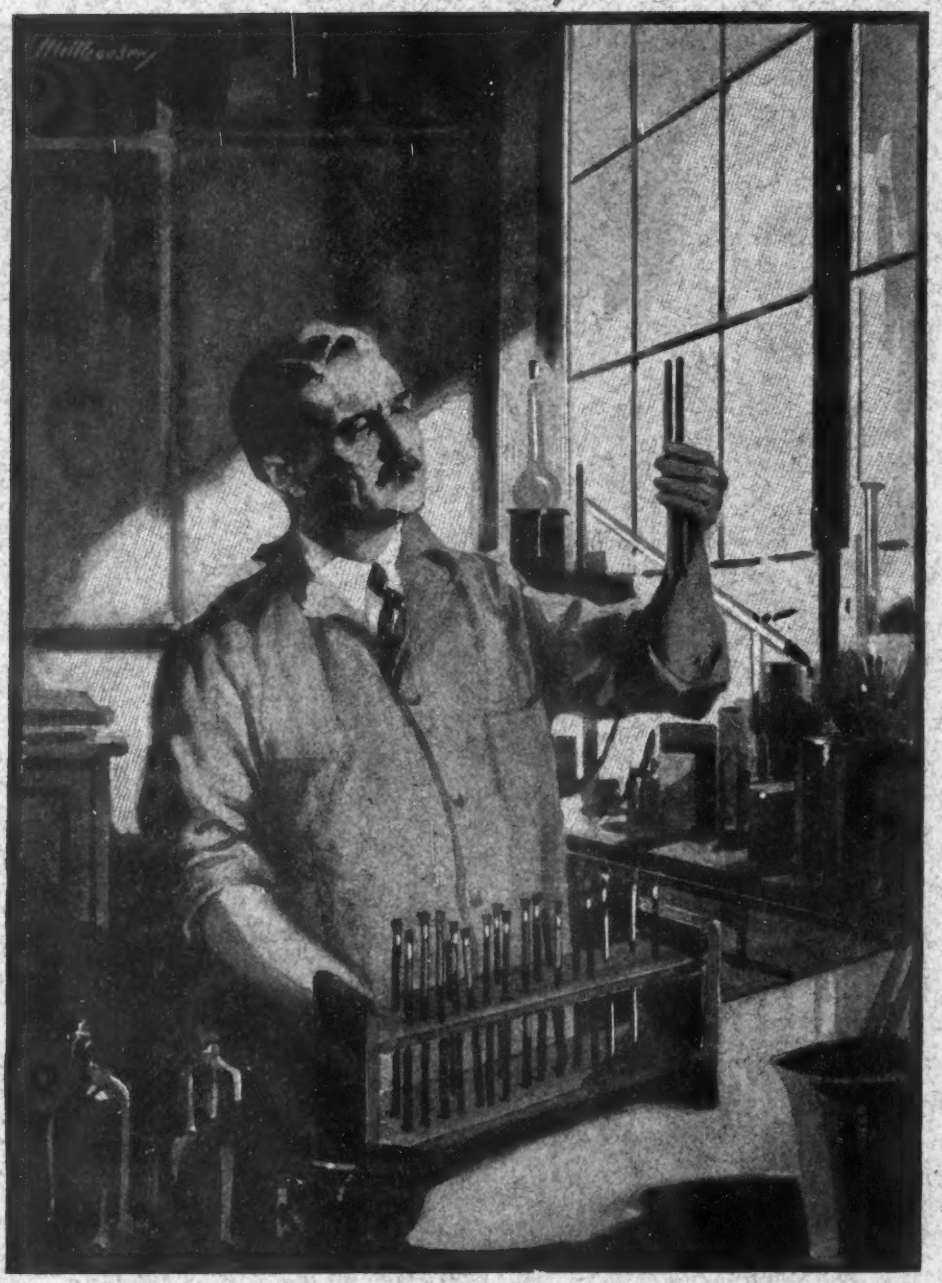

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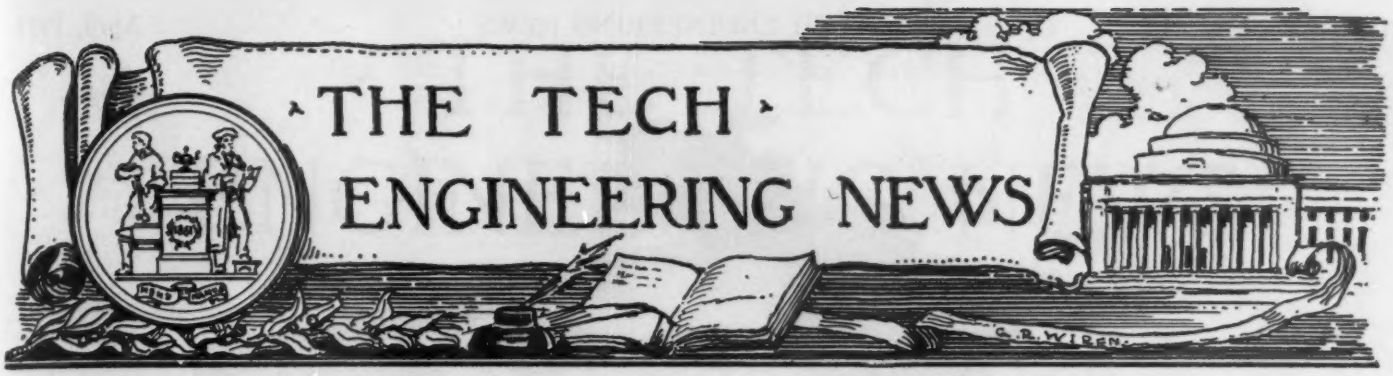

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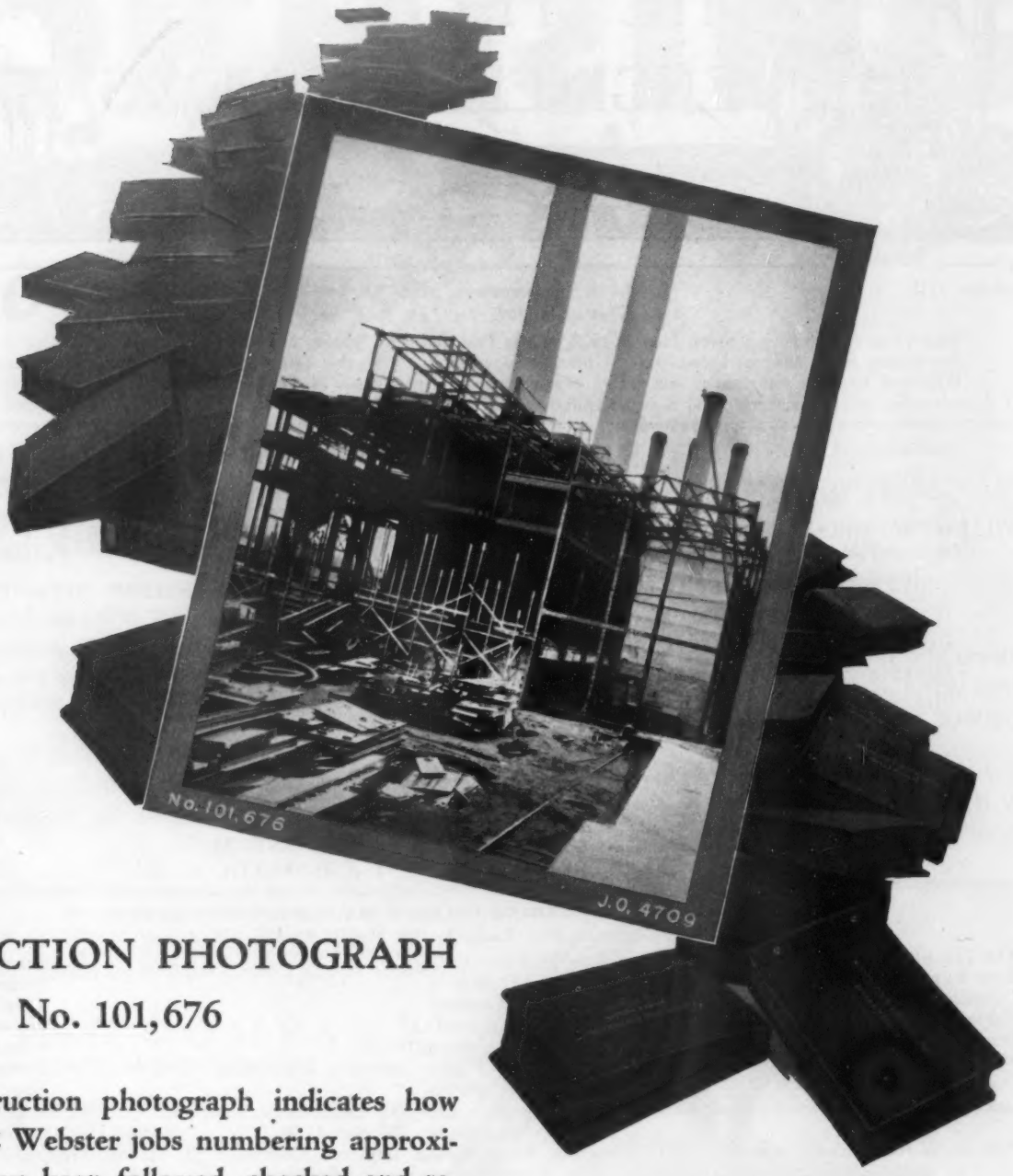

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THE PROFESSIONAL JOURNAL OF THE UNDERGRADUATES OF THE
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

VOLUME VIII APRIL, 1927 NUMBER 3

The Institute's Part in American Aeronautics

Aeronautical education and research at Technology

By C. H. CHATFIELD, '14
Associate Professor Aeronautical Engineering, Massachusetts Institute of Technology

AMONG educational institutions in the United States the Institute is unquestionably the pioneer in aeronautics. Professor Gaetano Lanza, for many years head of the department of mechanical engineering, first became interested in the subject more than thirty years ago at a time when flying was hardly more than a speculation. Many years elapsed between the time of Professor Lanza's first interest in the subject and the time when it was possible for him to express his interest in tangible form. About 1909, however, he built at the Institute what appears to have been the first wind tunnel in the United States. This consisted of a section of ventilating duct about three feet square and twenty feet long, through which air was forced by a blower driven by a nine horse-power motor. The maximum wind speed attainable was twenty miles per hour. Means were provided for suspending airfoil models in the tunnel and for measuring the forces on them with an apothecary's scale. Wind speed was measured by an anemometer and a pitot tube, so that this apparatus, while crude in form, nevertheless had in it the essentials of the modern wind tunnel.

Among those who worked in this tunnel were Professor E. F. Miller '86, Mr. A. A. Merrill, now at the California Institute of Technology, and Mr. Guy Lowell '94, who recently died after a distinguished career in architecture. It was with this apparatus that E. N. Fales '11 did work on center of pressure location on airfoils, the results of which were embodied in his thesis. In 1911 opportunities in aeronautical engineering were very limited, so Mr. Fales after his graduation had to go into other work, but he later was able to return to the aeronautical field and has for some years been in charge of the wind tunnel at McCook Field.

Professor Lanza's interest in aeronautics led also to a course of six lectures given about 1912 by Mr. Merrill. Attendance at these lectures was entirely voluntary and no academic credit was given for the work, but the interest of the students was so great that the course began with an attendance of fifty and ended with ninety-five. Dr. Maclaurin, who was then president of the Institute, was quick to recognize the opportunities presented by the new branch of engineering. In 1913 he was appointed by President Taft a member of a commission for the establishment of a national aeronautical laboratory, and in the same year he secured from the navy department the detail of Lieutenant, later Commander, J. C. Hunsaker to the Institute as instructor in aeronautical engineering.

Lieut. Hunsaker first spent a year abroad to familiarize himself with foreign aeronautics. He returned to the Institute early in 1914, and in the academic year 1914-15 a graduate course in aeronautical engineering was established, leading to the degree of master of science. This course was given under Professor Peabody, then head of the department of naval architecture, and Hunsaker was directly in charge of it. Among his early students were Donald W. Douglas '14 and Thomas H. Huff '15. By June, 1914, Hunsaker had in operation at the Institute the first modern wind tunnel in the United States. This tunnel, which was a replica of one at the National Physical Laboratory in England, occupied the first building erected for educational purposes on the present site of the Institute. It was four feet square, had a ten horse-power motor, and a maximum wind speed of forty miles per hour. In this tunnel Hunsaker did his well-known work in dynamic stability of airplanes during the years 1915 and 1916. During this same period the development of the U. S. A. series of airfoils was begun at the Institute by V. E. Clark, H. S. Martin, and E. S. Gorrell, all then army officers detailed to the Institute for instruction in aeronautics.

The increasing need for air forces made evident by the World War led in 1916 to the formation of an organization in the navy department to deal with its aircraft problems, and Commander Hunsaker was recalled from the Institute to Washington and placed in charge of all the work in aircraft design. He remained in this position during the war and for several years after. Instruction in aeronautics at the Institute was continued by Mr. Alexander Klemin, now in charge of the Guggenheim School of Aeronautics at New York University, who had graduated from the Institute in 1916.

The entrance of the United States into the conflict led the Institute to offer its services and facilities to the Government, and this offer was soon accepted. Ground schools for military and naval aviators were established in 1917. The Walker Memorial, then just completed, was entirely occupied by the Naval Aviation Detachment, and during the rest of the war the Institute remained the chief naval aviation ground school. Instruction in this ground school was in charge of Pro-

fessor H. W. Smith '97, and among the instructors later to be well-known in aeronautics were E. W. Rounds '17, and W. G. Brown '16.

As the war continued and the need for aeronautical engineers in the service became more apparent, the Institute established a special course in aeronautical engineering for army and navy officers. The first of these courses was given in the spring and summer of 1918 and the work was repeated for a second group of officers in a second course which began in September of that year and extended until January, 1919. Most of the instruction in aeronautical subjects was given by E. P. Warner '17. Among the students were Lieut. W. S. Diehl, who has for a number of years been in charge of the work of the Bureau of Aeronautics in aerodynamics, and Lieut. C. N. Monteith, who was for several years in charge of the Airplane Section at McCook Field and is now engaged in engineering work with one of the large aircraft builders.

In the period just after the war most of the work in aeronautics consisted of research done by army employees in the Institute's wind tunnel, and instruction given by members of several other Institute departments.

In. 1920 Professor Edward P. Warner, who had been in charge of the laboratory of the National Advisory Committee for Aeronautics at Langley Field, returned to the Institute to take charge of the instruction in aeronautical engineering, which was then transferred to the department of physics. The wind tunnel had been moved in 1918 to the present laboratory building, and in 1921 Professor Warner had it rebuilt into one of the Venturi type, four feet in diameter, and by his improvements raised the maximum wind speed from forty miles per hour to sixty with the same power plant. This tunnel is still in use.

In 1922, under Professor Warner's direction, a seven and one-half foot tunnel was built in which the maximum wind speed is ninety miles per hour. This tunnel is large enough to permit the use of quarter size airplane models, with stub wings, and these models can be tested in the presence of a propeller, so that conditions of full flight are much more closely simulated than in an ordinary tunnel.

Interest in the aeronautical course continued to increase, and many army and navy officers were detailed to the Institute by the government for instruction. Professor W. G. Brown, a specialist in aeronautical research methods, had joined the staff in 1922, and early in 1926 Professor C. F. Taylor, an authority in aeronautical engines and a designer of long experience, came to the Institute, so both instruction and research were still further broadened. By this time the interest in the course and the demand for its graduates had become so great that it was decided to make aeronautics one of the regular four-year professional courses, and Course XVI was accordingly established with Professor Warner in charge.

This four-year course is designed, first to train the student thoroughly in the engineering fundamentals, and then to familiarize him with the application of these fundamental principles to aircraft design, construction, and operation. The work of the first two years is almost identical with that in the course in mechanical engineering, and most of the time in the third year is still devoted to fundamental subjects. Professional work in aeronautics, however, begins in that year with a course in airplane rigging and maintenance, in which the student learns the main functions of the different parts of an airplane and by actual practice finds how one is assembled. The mathematical side of aeronautical engineering is introduced in the course in theoretical aeronautics, which deals with the application of fluid dynamics and rigid dynamics to airplane problems. In the fourth year an extensive course in airplane design is given and the application of the principles of airplane design are worked out in the drafting room by the students in making the calculations and drawings necessary for at least two airplanes. Instruction is given to familiarize the students with aeronautical engines and the student learns to operate these engines in the laboratory. Laboratory instruction is given also in wind tunnel work, and in this, as in laboratory instruction in chemistry, the Institute is a pioneer. The strictly aeronautical subjects are supplemented by work in dynamics of machines and in machine design, in physical chemistry, in testing materials, and in electrical engineering. As in the other Institute courses, each candidate for a degree writes a thesis which reports on original work done by him in some aeronautical subject. For graduates who wish to work for the master's degree in aeronautical engineering, advanced subjects are available. Advanced airplane design deals chiefly with problems of stability and control, and advanced airplane structures treats of the more refined and precise methods of structural analysis. Advanced wing theory covers the modern application of hydrodynamics to aeronautics developed by Prandtl in Germany. Extensive courses in aeronautical engine design and testing are available, as well as courses in propeller design. In addition to the subjects intended for students who are candidates for the degree in aeronautical engineering, courses are given also for students in other departments of the Institute. Among these latter students the officers detailed by the navy department for the naval constructors' course form an important group. The largest group of students, however, outside Course XVI, to whom aeronautical instruction is given consists of the men in the Reserve Officers Training Corps. These men are given courses in general aeronautics, and in airplane design, and this work, supplemented by ground and flying instruction during the summer, qualifies them for commissions in the Air Corps Reserve, and fits them for work in military aeronautical engineering if they should be called to active service.

Statistics compiled by the Guggenheim Foundation early in the present academic year showed that the forty-four students then enrolled in the regular aeronautical engineering course at the Institute constituted 46% of the total number of students working for degrees in aeronautical engineering in the United States. Freshmen and R. O. T. C. students are not included in this percentage. The Institute has half of the graduate students in aeronautical engineering in the country.

The work of the resident staff is supplemented by lectures given by prominent aeronautical engineers who are not connected with the Institute. Among those who have lectured during the past academic year are Dr. Theodor von Karman, who came from the University of Aachen under the auspices of the Guggenheim Foundation, and Mr. A. H. G. Fokker, the well-known airplane designer.

But the instruction of students is only part of the work in aeronautics done at the Institute. The research staff, under the direction of Mr. Shatswell Ober '16, is constantly employed in the investigation of new problems. The Institute's wind tunnels are available to airplane constructors and many tests for them have been made. The well-known Clark Y airfoil was first tested at the Institute, and it is interesting to note that this work was in effect only a continuation of earlier work by Mr. Clark in the same laboratory. It is worth noting also that the only wind tunnel operated by an aircraft manufacturing company is in charge of an Institute graduate, W. H. Miller '22. Much of the research work of the Engineering Division of the Air Corps at

(Continued on page 142)

Aeronautical Power Plants

A comparison of air and water cooled engines as well as discussion of the Diesel engine

By C. Fayette Taylor
Associate Professor of Aeronautics,
Massachusetts Institute of Technology

THE present situation with regard to power plants for aircraft is most interesting. While the fundamental type of engine used, that is the four-cycle gasoline engine, has not changed since the first flight made by the Wright brothers, continuous improvement and refinement in detail has made the airplane engine of today quite a different piece of apparatus than it was even so short a time as ten years ago. The goal which designers have considered the ultimate ideal, namely the development of a horse power for every pound weight of engine, has been well-nigh achieved in the F. I. A. T. engine which won the Schneider Cup Race this year. This engine, complete with water in the jackets, but without radiator and piping, weighed 1.03 pounds for each horse power developed. This is equivalent to approximately 1.6 pounds per horse power with a complete cooling system of the normal type. The development of the air-cooled radial engine is quite comparable with this, the Pratt & Whitney Wasp and Bristol Jupiter engines weighing about 1.5 and 1.6 pounds per horse power respectively complete with cooling system. Since the figures given for these two engines are based on their service ratings without any special forcing for racing purposes (as in the case of a F. I. A. T.), it is evident that from the weight standpoint the air-cooled radial is at the present time slightly ahead of the corresponding water-cooled installation.

The competition between the water-cooled and air-cooled engines for supremacy in the air constitutes one of the most interesting phases of the present situation. While the air-cooled power plant usually has a lower weight per horse power than the corresponding water-cooled power plant, there are still many engineers who feel that the water-cooled power plant possesses other advantages sufficient to offset this difference in weight. Accompanying this article are two illustrations showing the same type of airplane fitted with a water-cooled and air-cooled engine of approximately equal power. Figure 1 shows a Curtiss single-place "pursuit" airplane equipped with the Curtiss D-12 engine, a high speed, twelve-cylinder, V type, water-cooled power plant rated at 430 h. p. at 2250 r.p.m. The radiator is placed in a so-called "tunnel" just below the engine, and evidently occupies a relatively small portion of the total frontal area presented by the airplane. Figure 2 shows essentially the same airplane with the Pratt and Whitney "Wasp" air-cooled radial engine rated at 425 h.p. at 1900 r.p.m. At first glance it would appear that this type of engine offers considerably more air resistance than the water-cooled type owing to its exposed cylinders. It would also appear to restrict the field of vision of the pilot as compared with the water-cooled engine. While these objections are true to a certain degree, the difference is not so great as to be considered very serious by most pilots. The lighter weight of the air-cooled power plant gives the airplane a higher rate of climb and a higher ceiling than is obtained by the water-cooled power plant of approximately equal power, and the fact that the engine is shorter and more compact concentrates the weight of the entire airplane more nearly at its center of gravity, which, together with the lower engine weight, makes this airplane considerably more maneuverable than with the water-cooled power plant. In this connection it is interesting to note that a good measure of maneuverability in a fighting airplane is the shortest radius of turn which the airplane can make at full speed. That airplane which can turn in the shorter radius has a distinct advantage in bringing its machine guns to bear on an airplane which must use a longer radius of turn. The maximum speed of the airplane illustrated is very nearly the same for both power plants, with perhaps a slight advantage in favor of the water-cooled installation. Many competent authorities feel, however, that such a slight advantage in maximum speed is much more than offset by the advantages in climbing and maneuvering ability of the air-cooled installation. These advantages, considered together with the greater simplicity and ease of overhaul of the air-cooled radial, seem to justify the prevailing opinion that the air-cooled engine is distinctly superior to the water-cooled engine for most purposes under present conditions.

It will be interesting to observe the progress of this competition between the air-cooled and the water-cooled engines, and to note whether the air-cooled power plant continues to gain

Pictures through courtesy of Curtiss Airplane and Motor Co.

FIG. 1. CURTISS P-1B HAWK, ARMY TYPE, CURTISS D-12 ENGINE

FIG. 2. CURTISS F 6 C-4 "HAWK" NAVY LANDPLANE PRATT & WHITNEY "WASP" ENGINE

in popularity as rapidly as it has in the past two or three years.

The fact that the air-cooled power plant has the upper hand at the present time is emphasized by the tendency in Europe toward this type of engine. Many of the old established manufacturers, such as Lorraine Dietrich and Salmson, who have confined themselves almost exclusively to water-cooled engines in the past, have recently brought out air-cooled models. In England there is a distinct tendency toward the air-cooled radial engine although several water-cooled engines are also holding their own very well.

In the writer's opinion there is one consideration in favor of the water-cooled engine which may enable it to continue to compete successfully with the air-cooled engine in certain types of airplanes. This is the fact that the capacity for heat dissipation of an air-cooled cylinder is limited by the surface area of the cylinder itself and the fins which can be placed thereon. In the water-cooled engine, however, the cylinder area exposed to the cooling water is not yet the limiting factor,

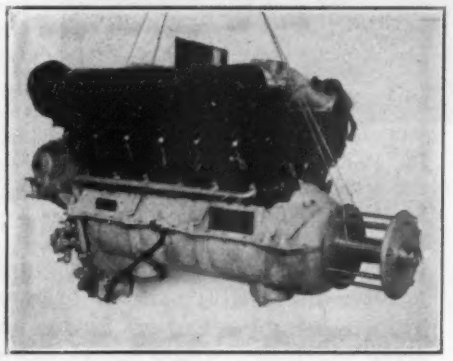


FIG. 3. CURTISS D-12 ENGINE

A twelve cylinder, water cooled "Vee" engine rated at 430 H.P. at 2250 R.P.M.—weight, with cooling system and water, approximately 890 lb.

and increased cooling may be obtained by enlarging the radiator surface and increasing the rate of circulation of the water. This means that in the development toward higher piston and crankshaft speeds which is now going on, the air-cooled engine may reach a limit beyond which the required rate of heat dissipation exceeds the capacity of the cooling surface. It seems quite apparent that if this limit exists at all in the case of the water-cooled engine, it will occur at a very much higher power per unit of engine displacement than in the case of the air-cooled engine. This is borne out by the results which have been recently obtained by racing automobiles operating at crankshaft speeds of over 6000 r.p.m., and developing a horse power on considerably less than one cubic inch of piston displacement. This figure has not been nearly approached in any air-cooled engine of which the writer is aware. Another method of increasing the power per unit of piston displacement is by the use of the supercharger. This is a form of air pump which delivers air to the engine at a pressure higher than atmospheric, thereby increasing the weight of intake charge and the power output. If this method of increasing power output is carried very far, it may be that the limitation of cooling surface in the case of the air-cooled engine will give the water-cooled engine an advantage.

While this keen competition is going on between the various types operating on the normal gasoline engine or Otto cycle, the intensive development of the fuel injection or Diesel cycle is being carried out both in this country and abroad with a view toward making it adaptable to the high piston and crankshaft speeds which are necessary for a light weight engine. The advantages of the fuel injection cycle for aircraft work are chiefly its ability to use a low grade fuel which involves much less fire risk than gasoline and is at the same time cheaper. It is also felt that the elimination of the electric ignition system will be of great advantage. The fuel injection cycle lends itself very well to the two-stroke type of operation in which there is a power stroke in each cylinder for every revolution of the crankshaft. Obviously if this two-stroke cycle were developed to a point equal to the four-stroke cycle, it would be possible to obtain twice the power from a given engine at the same speed, or to decrease the speed by one-half and still develop the same power. In this country the National Advisory Committee for Aeronautics has been conducting some very valuable fundamental research on fuel injection in their laboratories at Langley Field, Virginia. They have developed an apparatus for ultra high speed photography of the injection spray. Investigation by means of this apparatus has resulted in some very fundamental and valuable knowledge regarding the action of high pressure spray nozzles for introducing fuel into the very high pressure atmosphere existing in the cylinder of a Diesel engine just prior to the end of the compression stroke. This investigation has now reached a point where it can be safely said that the fundamentals of fuel injection, at least as regards the introduction of the fuel, have been definitely established, and it remains for manufacturers to take up the application of these fundamentals to the development of truly high speed fuel injection engines. In Germany, which was the birthplace of the Diesel engine, a great deal of valuable research and development is going on, and one company, the Maybach, has actually put on the market a high speed, automotive, Diesel engine. This engine is rated at 150 h. p. at 1500 r.p.m. with a fuel consumption from .39 to .44 pounds per brake horse power per hour. The weight is 2650 pounds or nearly 18 pounds per horse power. While this may seem excessive when compared to airplane

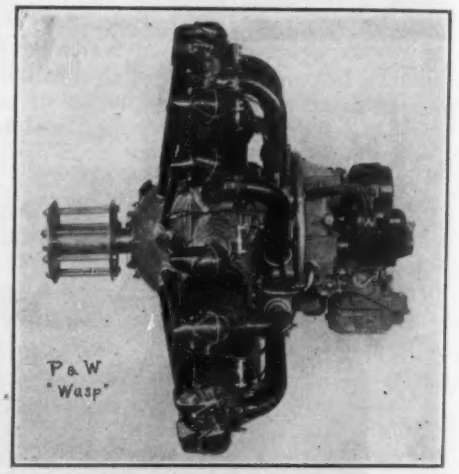


FIG. 4. PRATT AND WHITNEY "WASP" ENGINE

A nine cylinder radial air cooled engine rated at 425 H.P. at 1900 R.P.M. Weight, without oil or water—650 lb.

engines, it represents a distinct advance over earlier practice in the fuel injection field. In England the Beardmore Company is developing a large high-speed Diesel engine which is reported to be very promising. This particular development, however, is surrounded with the greatest secrecy. Reports are that it will develop 650 horse power with a weight of 3200 pounds and a fuel consumption of under .4 pounds per horse power hour. This is a weight of something less than 5 pounds per horse power which is exceptionally good for this type of engine. In this country the Navy is developing the Attendu oil engine for air-craft work, but so far this engine is in the experimental stage only. Several American companies are developing injection engines for automotive work.

The difficulties to be overcome before the fuel injection engine will compete with the gasoline engine for aircraft service, are very great. Nevertheless astonishing progress has been made, and it will be interesting to watch further developments. Since the fuel injection engine may not lend

(Continued on page 152)

Metal Aircraft

The advantages and disadvantages in using light aluminum alloys instead af fabrics for coverings

By Roy G. Miller
Engineer, Naval Aircraft Factory
Philadelphia, Pa.

THE United States Navy has long appreciated the many advantages of metal aircraft construction as compared to wood and has done much to foster its steady development. Private manufacturers have been encouraged by contracts for experimental construction and the Bureau of Standards and Naval Aircraft Factory have undertaken a great deal of pure research and experimentation on Navy funds.

While the Army and many of the private manufacturers have favored use of steel in metal construction, the Navy was quick to realize the advantages of the light aluminum alloys and has concentrated the greatest effort on their improvement and application. By far the greater portion of the structural weight of an airplane lies in the compression members. Assuming geometrically similar sections an Euler column may be provided in duralumin weighing only sixty per cent as much as a steel column designed to support the same load. This quality in duralumin is due principally to its low specific gravity providing bulk in compression members. In the case of tension members where bulk is not desirable, the best alloy steels are preferable to duralumin.

The greatest single difficulty which has been encountered in the use of aluminum alloys has been susceptibility to corrosion. Properly heat-treated duralumin, insofar as corrosion is concerned is somewhat worse off than the grades of aluminum ordinarily used for cooking utensils. It has been found that the proper heat-treatment for realizing the best physical properties of duralumin is fortunately the same for developing the greatest resistance to corrosion. Quenching in cold water from 500 to 510 degrees centigrade is the approved treatment. Annealed duralumin is particularly susceptible to "intercrystalline corrosion," the bogy which has excited much comment lately. Proper heat treatment refines the granular structure of the metal and keeps most of the $CuAl_2$ in solution where it belongs rather than permitting it to distribute itself very liberally around the margins of large grains. Protection and maintenance problems with duralumin are very similar to those encountered with steel. Various paints, varnishes and grease have proved to be helpful. There has been no non-corrosive metal coating developed, however, which is electro-positive to duralumin and which will offer the same protection which zinc offers to steel. The "anodic" treatment, in which an oxide coating is applied to duralumin by electrolysis, has shown very remarkable results, particularly when used in conjunction with various of the organic protective coatings.

Duralumin lends itself to various manufacturing processes because of its relatively high ductility immediately after heat-treatment. Shaping after heat-treatment eliminates the possible warping due to heating and quenching besides insuring high physical properties. Cold working brings about a substantial improvement in the physical properties.

Early metal construction of aircraft in this country leaned toward the "all metal" types of the German Junker and Dornier machines. The thinnest aluminum alloy sheets which it has been found practical to use for covering the wings of airplanes is several times as heavy as fabric. The only justification for its use lies in the possibility of its contributing to a portion of the structural strength. The Junker machines have consistently held to the corrugated wing covering contributing to the rib strength. The early Dornier machines employed a smooth metal covering designed to carry a portion of both rib and spar stresses. Sand load tests at the Naval Aircraft Factory indicate that a suitably stiffened metal covering will carry a maximum unit stress of from 20,000 to 23,000 pounds per square inch. One of the chief advantages claimed for the metal covered wing is its resistance to torsional deflection. That this quality, taken alone, is not all-important is demonstrated by the reports from abroad indicating structural failure, due to wing flutter, of two Dornier pursuit planes. It seems important to combine with torsional stiffness an airfoil of good stability characteristics and a structure with its gravity axis well forward. A good modification of the metal covered wing was embodied in several Dornier models in which the forward portion of the wing was metal covered and the rear portion fabric covered. It is rather interesting to note that the latest Dornier wing (on the "Superwal") is fabric covered. Another German constructor, Rohrbach, has developed a very interesting wing, covered with smooth metal. The first all metal airplane which the United States Navy undertook was the NM-1, somewhat lighter and more efficient than the Dornier construction but very similar.

The present trend on Navy projects is toward fabric covered metal structures. It has been found that metal structures may be built which weigh about half as much as conventional wood construction. A few of the structural features which have contributed most to weight saving are the following:

(a) Cambering of structural members subjected to combined axial and distributed loads to reduce or eliminate secondary stresses.

(b) Eccentric fittings for the reduction of stresses in principal members.

(c) Eccentric structural sections to distribute material according to loads.

(d) Dependence upon friction to increase the strength of self-aligning compression members.

The development of metal construction at the Naval Aircraft Factory has aimed at a combination of light structural weight, serviceability and low cost of production. Parts are designed with the idea of mass production, in case of emergency, constantly in mind. It was this consideration which has led the factory to do considerable work in pressed metal construction. It has been found extremely difficult to compete with tubular members on a basis of strength-weight in the case of extremely light and fragile members, such as ribs, but hope is entertained of closely approaching the built-up tubular wing beam with pressed construction. One of the chief advantages claimed for pressed construction is its freedom from reliance upon a multiplicity of fastenings for its primary strength.

Ancient Methods of Engineering

The engineering features used in the construction of the Pyramids

By ASHTON SANBORN
Secretary, Boston Museum of Fine Arts

PHYSICAL environment is one of the chief influences affecting the development of racial culture, especially that of a people geographically isolated from contact with other civilizations. In the Nile valley conditions for many thousands of years have been favorable to man, and we may trace Egyptian life and activity backward in diminishing historical perspective into the Late Stone Age of the fifth millennium B.C. In its conditions of climate, soil, isolation, and available raw materials, Egypt is unique among the river valleys of the earth which have brought to birth and fostered one great nation after another. Protected on the north by the Mediterranean Sea, on the east and west by inhospitable deserts, and on the south by both the desert and the rocky barriers of the cataracts; offering within itself a climate ideal for human comfort; the rich agricultural resources of a soil annually renewed by the Nile flood; the Nile itself an avenue of easy communication from one far end of the country to the other; mud and reeds and wood for building shelters and boats; mud and beds of clay for making bricks and household pottery; flint in the limestone cliffs for chipping out implements, weapons, and ornaments; a great variety of hard beautifully colored stones for fashioning vessels; limestone, granite, alabaster, and basalt for building material; deposits of gold, of silver, and of copper ore, —all these elements combined to spur the inhabitants of this favored and protected land to evolve at a very remote period a civilization of distinctive character which persisted almost without change for over four thousand years.

The nomadic herdsmen of prehistoric times in the Nile valley, like the Indian tribes of North America, made no permanent settlements, but built for themselves temporary shelters of mud-plastered reeds while waiting for the quick-growing crops of grain to ripen before they moved onward to fresh grazing ground for their flocks. In this early age originated the crafts which through centuries of repeated practice schooled the Egyptian in patience and ingenuity when dealing with obdurate materials, and in that remarkable coordination of eye and hand which led on to the highly developed arts of historic times.

When the tribes of the valley and the delta had at length been organized into a state, probably soon after 4000 B.C., under the leadership of Menes, first king of the First Dynasty, we find the Egyptians using bricks of sun-dried mud as the simplest, cheapest, and most readily obtainable building material. Mud bricks are widely used today in Egypt by the peasants, still made as of old; they are one of numerous survivals from the remote past which bear witness to the permanence of things Egyptian. Nile mud possesses a naturally tenacious quality, increased by the addition of chopped straw; it is available in unlimited quantity and from it a large number of bricks can be easily moulded in an incredibly short time. Under the favorably dry conditions of Egyptian climate structures of sun dried bricks have stood for some five thousand years. The ancient bricks were large, an average size being 15″ x 7″ x 4½″; they were laid up in a mortar of Nile mud, and elaborate systems of bonding were contrived in order to strengthen the construction. Courses were laid as headers and stretchers, not always alternately, however, and careful attention was given to breaking joints. Nor were the bricks all laid on the broad side, as in modern construction, but one or more courses laid on the broad side alternated with other courses laid on the narrow side. Walls of crude brick were usually very thick, and additional stability was secured by giving the faces a pronounced batter. In long stretches of wall, such as surrounded the precincts of a temple or a fort, vertical sections in the shape of truncated wedges resting alternately on base and on apex effected a solidity of structure which the force of gravity seems actually to have increased. Crude brick was the common material used for secular buildings, even for the palaces of kings, throughout historic times, stone, when once it came into use, being chiefly employed for temples of the gods and for the "eternal dwellings" of the dead whose spirits required a permanent abode of imperishable nature. The roofs of mud-brick structures were also of mud, resting on beams of palm logs or of tougher hewn timbers. Egypt never produced large timber in any quantity suitable for building, so that fine lumber had to be imported from

EXCAVATING PARTY AT WORK

Clearing away the great casing blocks of red granite that have fallen from the third pyramid at Giza.

the great cedar forests of the Lebanon Mountains. Except over narrow passages and small rooms, the roof required the support of tree trunks as props at proper intervals; thus the column became naturally at an early date an essential feature in Egyptian mud-brick buildings, with a base of stone to give it secure footing and an abacus of wood at the top to distribute the superincumbent weight. The corbel vault and leaning course arch built of mud brick were used before 2500 B.C. to roof passages.

Stone architecture developed from the older mud-brick architecture, translating the details of mud-brick and wood construction with what seems often to be unnecessary fidelity into the costlier and more permanent material. Stone appeared first as an accessory to mud-brick masonry before the year 3000 B.C. in units of comparatively small size employed like their mud-brick prototypes. The technique of manipulating the new material developed rapidly, and after a few generations Egyptian builders were piling up huge blocks of limestone and of granite in the royal pyramids and in the mastaba tombs of nobles of the Fourth Dynasty at Giza, were erecting temples with monolithic columns and great roof-beams of stone, and in the Eighteenth and Nineteenth Dynasties surpassing even their earlier amazing feats of engineering by setting up granite obelisks and colossal statues of enormous weight. The largest surviving obelisk carried off by Constantius, son of Constantine the Great, to Rome where it now stands before the Lateran, weighs over 450 tons; it was originally set up in the temple of Amon at Thebes by Thothmes IV shortly after the year 1420 B.C.

The problems involved in quarrying, transporting, and erecting stones of such great weight without the aid of modern machinery have given rise to much discussion. On the monuments themselves even kings boast of their architectural achievements, and in the tombs of master architects contemporary documents in the form of funerary inscriptions record the successful accomplishment of formidable engineering tasks; furthermore on the walls of temples at Thebes and elsewhere in sculptured tombs are pictured actual scenes showing the transport of colossal statues and huge obelisks by land and by water. Other evidence is found in the quarries and in existing structures,—especially in unfinished structures.—of the methods used by the Egyptian builders. In meeting all the exigencies of life the Egyptian was intensely practical, and he had developed the qualities of ingenuity and patience to an extraordinary degree. Besides these qualities inherent in the race, the social organization of the state throughout the historic period gave the king and his representatives despotic control over the masses of the people, so that man power was available in large and constantly renewed quantity, at the low cost simply of feeding, for carrying out any enterprise, however prodigious. When some great royal work was under way, an army of men was sent to the quarries. Certain of the finer stones were found only in desert regions where conditions of life for the workmen must have been such as would make Siberia seem a fair paradise. The tools for getting out the stone were themselves principally of stone, although copper implements of a certain degree of hardness were known. A trench wide enough for a man to work in was cut around each block, and the block finally loosened from its bed, as a rule, by undercutting at intervals, inserting wooden wedges, and pouring in water until the swelling wedges lifted the block. In granite quarries fire was also used to disintegrate the stone in working out the blocks. Ramps were constructed from the quarries to the river bank, in order to offer a firm roadway for the wooden sledges on which the blocks were transported. Such sledges are represented on the monuments, and actual remains of practicable sledges still exist. For conveying very heavy stones, rollers may have been used under the sledges, although evidence for this is not conclusive. The surface of the road was wet to lessen friction, and the sledge was dragged along by a great number of men pulling at the ropes. On the river special barges conveyed especially large blocks, such as obelisks, to their destination, and from the river bank the blocks were dragged up another ramp to the building under construction. The great pyramids at Giza were built in an especially favorable location, in as much as the blocks could be quarried on the spot, only the fine casing stones for the First and Second Pyramids had to be brought from the quarries across the river at Turah, and the casing of red granite for the Third Pyramid from the far distant quarries near Assuan at the First Cataract. Construction ramps of mud brick or of masons' debris were built upward as the building itself rose, and the blocks dragged up the incline. In careful work such as temple walls, the blocks of each successive course were floated into exact position on a thin bed of cement. In placing roofing beams and roof blocks of stone in position the entire space of the room below appears to have been filled in solid with debris in order to give a working platform, and to have been cleared out finally when the roof was finished.

A problem which has been considered with much interest in connection with the building of the pyramids is the relation of the construction ramp to the pyramid. Obviously the ramp

(Continued on page 150)

TEMPLE OF THE THIRD PYRAMID AT GIZA

Some of the limestone roofing slabs are still in position. Note the large limestone slabs in the rear wall.

Aeronautical Research

Research in flight and in the variable density wind tunnel

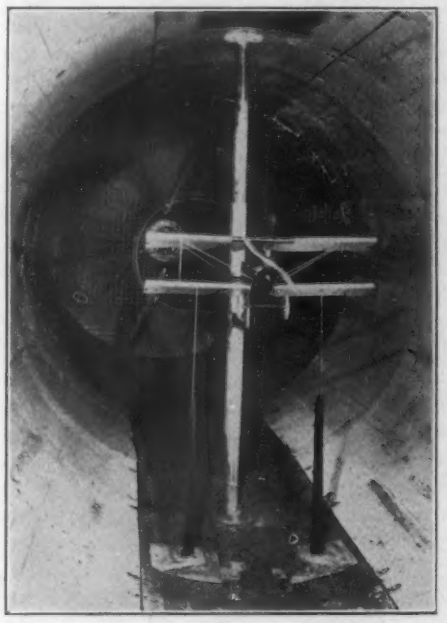
By JOHN W. CROWLEY, '20
AND GEORGE T. HIGGINS

THE National Advisory Committee for Aeronautics conducts a research institution at Langley Field, Virginia, whose facilities for the conduction of all types of aeronautical research are probably the best in existence. In one unit, and located on an excellent flying field, are laboratories for wind tunnel, power plant and flight investigations. Together with these are shops and laboratories for the construction and test of the necessary apparatus and instruments and a complement of usually a dozen airplanes for exclusive use in flight researches.

Anyone who has attempted to make observations in an airplane flight test realizes the difficulty, and must realize the impossibility of depending on personal observation to obtain accurate flight data. As a consequence of this, from its conception, flight testing has been very closely allied with the development of suitable recording instruments, and in many flight researches the far greater portion of the work is on the development of apparatus and instruments. It is not the intention of this article to dwell on the flight instrument problem other than to emphasize the close relation between flight testing and instrument development and to describe in a very general way the operation of some of the more important instruments. A complete description of the apparatus and instruments may be found in the Technical Notes and Reports issued by the National Advisory Committee for Aeronautics. All of the flight instruments developed by the National Advisory Committee for Aeronautics are dependent upon some photographic process for recording the measurements. In a few cases, usually where the time element is of little consequence, it is sufficient to photograph a group of the ordinary indicating type navigation instruments. In most instances, however, it is necessary to obtain continuous records, and for such tests a recording process which uses the traces of a light beam on a moving photographic film has been standardized. The film containers for these instruments are constructed to permit daylight loading and are interchangeable between instruments. When more than one instrument is used they are operated by a common switch and synchronized by means of lines placed simultaneously on all the records. The following are sufficiently representative to indicate the type of instruments developed to date: Accelerometers, rate of turn instruments, air speed recorders, altimeters, control position recorders, control force recorders, flight path angle recorders, etc.

As is usual with any science in its infancy, there are an almost unlimited number of problems in aeronautics that require experimental research. This is true of research in flight, and there will be no attempt to describe anything more than a few of the problems and tests that are of the greatest importance at the present time.

Of the flight tests made by the National Advisory Committee for Aeronautics, at the laboratory, the tests to determine the loads and forces experienced by aircraft in maneuvering flight are probably of the most immediate value. While many of the problems associated with flight may be solved in wind tunnels, at least approximately, work involving maneuvers of aircraft are at present beyond the ability of wind tunnel testing and consequently the aircraft designers are dependent on flight tests for a knowledge of the structural loads to design for. The simpler load measurements, i.e., the determination of total loads, are made by means of accelerometers, which instruments, as their name implies, measure the acceleration of the aircraft. Knowing the acceleration, the total force or load can, of course, be determined. Of considerably more importance, however, from the design standpoint is the determination of the distribution of load over the aircraft or over a particular part of it. This is determined by measuring the air pressures over the surface desired. In such tests a recording manometric instrument capable of measuring 60 pressures continuously over a period of time is employed. Tubes are run from the points of the surface being investigated to the manometer, and their open outer end is arranged flush with the surface. The air pressures experienced on the surface are transmitted through the tubing to the manometer, where they are recorded. In such a manner tests have been carried out on airplane wings and tail surfaces, the envelope and tail surfaces of a non-rigid airship, the tail surfaces and a portion of the hull of a rigid airship, the U. S. S. Los Angeles, and tests are now in progress to measure the air pressure distribution over the entire supporting surfaces of a modern pursuit airplane. The information obtained from such researches are primarily valuable for strength analysis of airplane maneuvers and for studies of airflow conditions in accelerated flight.



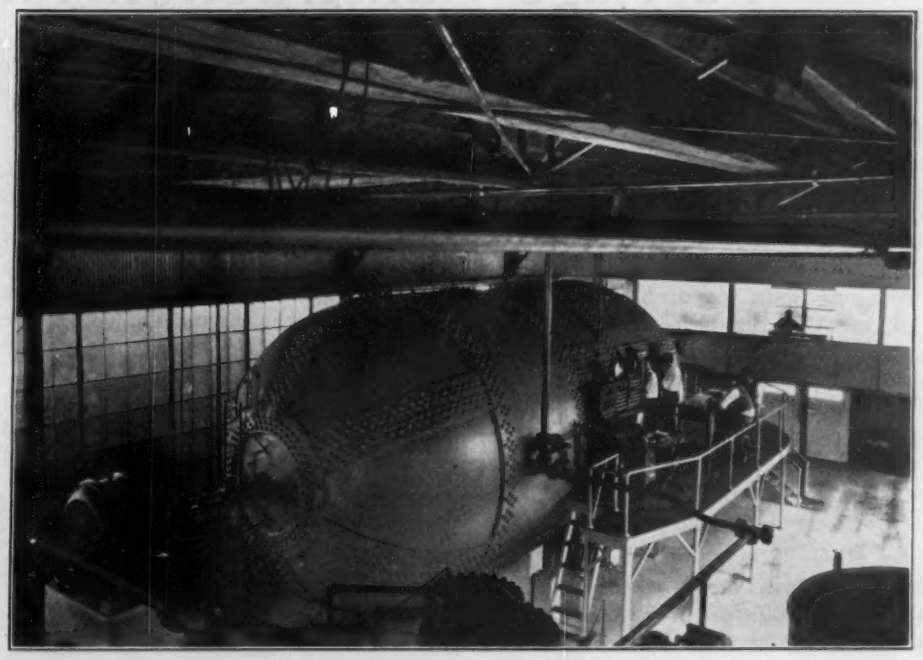
"National Advisory Com. for Aeronautics, Langley Field"

FIG. I. VIEW SHOWING MODEL MOUNTED READY FOR TESTING

The purchase and maintenance of full scale airplanes and the instrumental requirements make flight testing very expensive and wherever possible should be replaced with wind tunnel model tests. It was mentioned previously that maneuvering flight is at present beyond the abilities of wind tunnel testing, but what is still more unfortunate is that even the steady flight conditions in many cases are not sufficiently accurately duplicated in the usual type of wind tunnel to permit accurate full scale performance estimates from model data. One of the greatest fields for flight research, therefore, is to provide sufficient data on full scale airplane characteristics and performance from which definite laws can be established whereby full scale airplane performance can be calculated from wind tunnel data. The first and most important step in establishing the relation between full scale and model work is with respect to the lift and drag characteristics. This re-

lation is found by measuring the lift and drag of an airplane in flight and comparing with similar measurements on a model of the same airplane obtained in a wind tunnel. The flight measurements are accomplished in what are known as "glide tests." The airplane is glided with the propeller turning at the speed necessary to exert no thrust for the airspeed at which the airplane is gliding (predetermined for each gliding speed.) The flight path angle (the angle of the flight path relative to the ground) is measured by means of a streamlined instrument suspended below the airplane out of the air disturbed by the airplane's motion. This instrument is provided with stabilizing tail surfaces and takes up a path through the air parallel to that of the airplane. An enclosed pendulum records the angle of the instrument relative to the earth and a pitot static tube in the nose connected to a suitable manometer records the airspeed. Since the propeller is exerting no thrust, the movement of the airplane is due entirely to its weight. Knowing the angle of the flight path and the weight, the latter may be resolved into a component along the flight path, which is equal and opposite in direction to the drag of the airplane and another component perpendicular to the flight path which is equal and opposite to lift. In theory, glide tests are simple. In practice, however, because of the ascending and descending currents in the air, the conditions are seldom satisfactory except in the early morning and late afternoon hours when experience has shown we may expect the smoothest air. Other difficulties which are encountered, such as corrections for improper propeller speed, etc., complicate the measurements so that it is only by making repeated flights and balancing out errors that accurate data is obtained. Tests of this kind have been made on a number of airplanes, the most important to date being tests of an airplane equipped with six different sets of interchangeable wings, all wings being of commonly used airfoil sections. Tests very similar in character have been made using a family of airplane propellers for the purpose of determining possible errors and the correction for wind tunnel model propeller tests.

Other problems in flight research are those that arise in connection with the controllability, maneuverability and stability of aircraft. In this field theory has advanced far beyond the experimental work, and much of the theory must be confirmed before its final acceptance as applicable to actual flight conditions. From another standpoint, the designer is mainly interested in quantitative values from which he can determine the factors that are responsible for improvements in these characteristics, and it is only by comparative flight tests of different types of airplanes that such measurements can be obtained. To date there have been very few quantitative measurements on maneuverability and controllability, and to a lesser extent on stability. This is mainly because of the difficulty of this type of testing and the immense amount of labor that is involved in carrying out tests on a sufficient number of airplanes to make the information obtained of value. This type of flight testing, probably more so than any other, is dependent upon the use of recording instruments and special apparatus. At present maneuverability and controllability tests have only been carried to completion on one airplane. The tests are, however, being continued to embrace all types of airplanes.



National Advisory Committee for Aeronautics, Langley Field, Va.

FIG. II. GENERAL VIEW OF VARIABLE DENSITY WIND TUNNEL

Space prohibits the description of flight researches other than those mentioned previously, but the following list of problems is indicative of the scope of the flight researches conducted by the National Advisory Committee for Aeronautics: investigation of seaplane planing characteristics, landing force measurements on seaplanes and airplanes, landing and taking-off characteristics of airplanes, tests of auxiliary airplane apparatus such as variable camber wings and special controls, investigation of airship turning characteristics, tests using flying models for studying maneuvers when full scale maneuvers have proven dangerous, etc. Reports of the research work are published by the National Advisory Committee for Aeronautics.

There are four wind tunnels located at Langley Memorial Aeronautical Laboratory at Langley Field; one five foot throat, closed chamber Eiffel type; one six-inch open jet, return channel type; one twenty foot open jet, return channel type (not yet completed); and the variable density tunnel. The first three are, in main, similar to others of the atmospheric density type throughout the aeronautical world and in which an effect of "scale" is determined by changing the tunnel throat velocity. The variable density tunnel, however, differs from these, primarily, in that the velocity is held constant and the density of the tunnel air is changed to determine the scale effect. This effect can be almost entirely eliminated in that tests can be made under equivalent full scale conditions. It has been found that by maintaining constant the expression, $\frac{p\,v\,l}{u}$ [called Reynolds Number, where

p = density of the fluid,
u = specific viscosity of the fluid,
v = the velocity of fluid,
l = a characteristic length (the chord of an airfoil, airplane, the diameter of an airship, etc.)], the aerodynamic characteristics of an object exposed to a wind in a tunnel or in the free air are unaffected by the size

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Fuselage Construction for Airplanes

Interesting comparison between stick and wire and steel tube construction

By CHARLES T. McCARTHY, '16
Chief Engineer Chance Vought Corp.,
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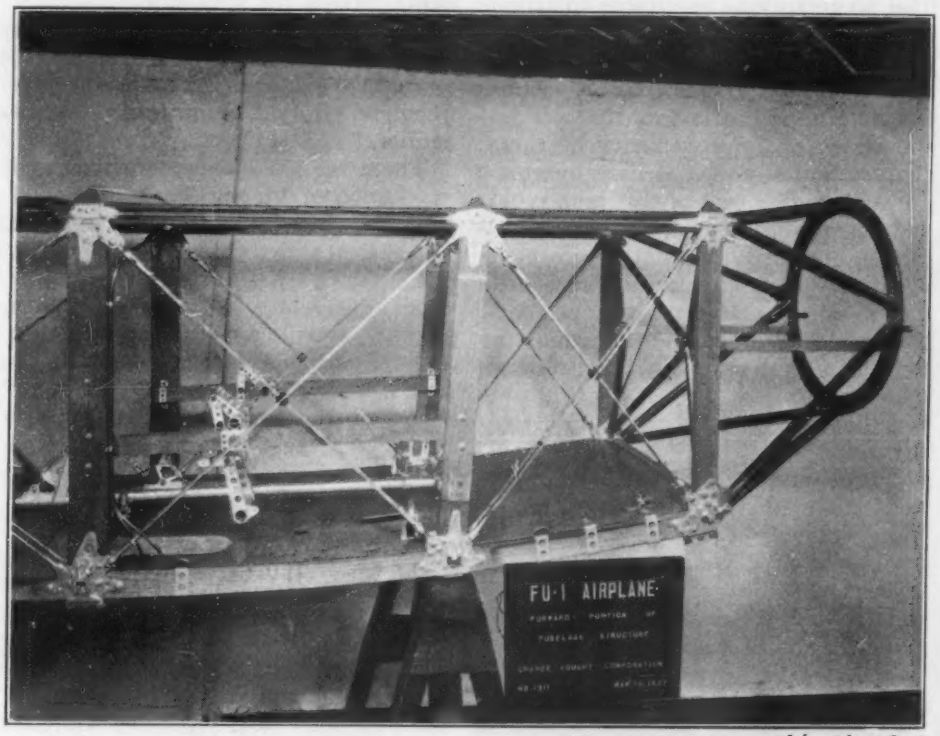
THE essential part of any airplane is the wings and control surfaces for without wings flight is impossible; but if the airplane is to possess practical utility it must be capable of transporting something from one point to another. To house conveniently the personnel or articles carried, as well as to provide for the manifold accessories of controlled flight, the power plant, fuel, controls, etc., a body of some sort is necessary. The body, or fuselage, then takes on an importance second only to the sustaining medium and has developed into an elaborate structure.

Recent years have witnessed an interesting evolution in body construction. It would appear that the day of the plywood-sided monocoque fuselage has definitely passed, that the wooden stick and wire construction is on the wane, and that the use of some sort of metal framing is definitely and rapidly becoming universal.

It may be of interest to examine the forces which are furthering this development. It will be helpful, perhaps, if this discussion is preceded by a brief description of a typical wooden and a metal framed fuselage.

A well known example of highly developed wood construction is the fuselage frame of the Vought FU-1 Airplane, a Single-Seater Naval Gunnery Training Airplane powered with an air-cooled engine, incorporating a Root's type supercharger. With the exception of the engine mounting, the structure is identical with that of the fuselages which have been employed in Vought UO-1 and VE-7 airplanes used so extensively thruout Naval Aviation for general observation and scouting planes, both as landplanes and seaplanes operating from shore stations, on the aircraft carrier U. S. S. "LANGLEY," and on the catapults of battleships and scout cruisers.

The longerons and struts of the fuselages are made of spruce in the rear portion where the loads are comparatively light, ash being used for the longerons and many of the struts in the more highly stressed forward portion. The details of the forward end are very clearly shown in Fig. 1 which also gives an idea of the complexity of some of the fittings. This complexity of parts is a concomitant of wooden construction; the longerons are the only continuous members and consequently fittings must be designed to transfer the loads at each joint from one member to another, paying attention to the necessity of obtaining adequate fastening in the wooden members to dispose of the loads without crushing the wood fibres or splitting out the end of a member. Considering that the structure of the FU-1 fuselage has been designed to take both wheel type and float type landing gears and to withstand the heavy concentrated loads developed when the airplane is shot from a catapult, it is apparent that these fittings have a lot of work to do. They are also a considerable item of weight. In the FU-1 fuselage the fittings and the bolts by which they are anchored to the wood structural members, weigh 35 pounds, or 23 per cent of the total weight of the fuselage frame, including the motor mounting.



John Adams Davis

FIG. I. FORWARD PORTION WOODEN OF FUSELAGE STRUCTURE

Of metal fuselages there is a considerable variety. There are fuselages of the Junkers and Dornier types where a duralumin skin is used as the primary structural member, and there are fabric covered fuselages of steel and duralumin, and combinations of both materials, usually fabricated of round tubes joined together in various ways. Lack of space prevents a description of more than one type and a fuselage of welded steel construction has been chosen as representing the most frequently used type.

The general arrangement of the structure is shown in Fig. 2. This is a photograph of the fuselage of the new Vought "Corsair," a high performance Observation-Fighter Airplane recently completed for the Navy Department and equipped with a P. & W. "Wasp" 400 H.P. air-cooled engine. The tubing used in the frame is of chrome-molybdenum steel, giving a tensile strength of 95,000 pounds per square inch, and is the most suitable material obtainable at present for this purpose. The fabrication of the joints is accomplished much more easily than in a wooden fuselage; for example compare the details of the joint shown on Fig. 3 with the corresponding joint of the FU-1 fuselage. This joint, too, is perhaps the "busiest" one in the fuselage. The engine mount and front flying wires are attached to it, the front strut of both wheel type and float type landing gears and the diagonal bracing of the float struts all come to this joint. Provision has been made for the accommodation of a total of thirteen members which meet here. In spite of

(Continued on page 136)

Open House Night

Laboratories and activity offices open to the public. April 30

OPEN House Night, when originally started by the Combined Professional Societies, was a mere exhibit of Technology's superb technical equipment, but it has now far outgrown its original purpose as was demonstrated last year when 15,000 people attended our "at home" night. This year many innovations have been made that will make Open House Night the biggest Technology function of the year.

The Open House Committee of the Combined Professional Societies, working with a committee of the faculty appointed by President S. W. Stratton, has decided to extend the time of the affair from one evening only to a full day, starting at 2:00 P. M., Saturday, April 30, and continuing until 11:00 in the evening. These changes were made in order that more Tech alumni and parents of the students may attend. It will further allow them more time to roam the buildings and chat with their classmates. To meet this end, the various classes have been assigned definite rooms and meeting times so that they may know just when and where they can meet each other.

FIG. I. DINING HALL, WALKER MEMORIAL

Heretofore, only the laboratories have been in full operation, and many of our guests have departed with the old feeling that Tech was a workshop and "factory" despite the ever-present effort of the undergraduates to kill that idea. This year the Walker Memorial Building is going to be the center of attraction, and in it at all times, the undergraduate activities will be holding open houses of their own in the various activity offices, and each will supplement their welcome with a demonstration and exhibit of their own, showing their contribution to the whole of Technology life and to their own staff in particular. The Tech Show has plans for presenting some of the skits that were successful in this year's show, and the Athletic Association will put on several boxing and fencing matches with demonstrations and equipment representing the other sports and teams. Technique is presenting an exhibition showing the complete assembly of the year book "from October to the publication date." The Tech is to distribute 5000 copies of their Special Open House Issue and all of the activities will be running at full blast, as they always are.

A concentrated effort is being made this year to invite all the secondary school men in New England who are planning to attend Technology next year, to come here for the day, so that they may get acquainted with their future college and her activities before they enroll.

With twice as much time allotted to the demonstration than heretofore, it is expected that every department and laboratory will have even a better exhibit than last year. The R. O. T. C. officers have consented to act as guides, but, as was found last year, most of the visitors prefer to roam as they choose rather than follow a fixed route, and the guides this year will be stationary, explaining a particular piece of apparatus and directing the people to the next point of interest. A very comprehensive system of signs is being worked out for all parts of the building, directing the visitors from place to place. The success of the day will depend on the coöperation of every person connected with Technology. It will be necessary that every student be present either on the board of his activity, as a guide, or at work in a laboratory. With the affair occupying both an afternoon and evening, every student will have the opportunity to go the rounds himself and still put in several periods at his own particular station.

As each alumnus and visitor enters he will be given a program that will tell him immediately what there is to see and how to reach it. In the Main Lobby, from 7.00 to 9:00 in the evening, President Stratton will hold a reception for the returning alumni and the parents of the students. The various activity heads have been asked to act as ushers for this reception, and a Technology orchestra will play on the second floor of the lobby. In the case of a single demonstration or experiment the time will be announced, and it will be repeated in the evening after the afternoon performance.

The visitor will do well to follow a more or less systematic route if he is to see all that will be going on. In the beautiful Main Library, under the central dome, the full force will be in attendance, and the stacks will be open to inspection. A novel pendulum experiment will also be under way to demonstrate that the whole world revolves about Technology and that Boston really is the hub of the universe. Pamphlets will be distributed to explain the principle which produces this effect. Descending from the dome, the visitor will pass through the laboratories of the Biological, and Public Health departments, and the Fisheries laboratory. Continuing to the second floor is the largest lecture room, 10-250, equipped with the most modern devices for the presentation of

(Continued on page 138)

The Pictorial Section

WHILE Aeronautics is one of the youngest sciences it has made rapid progress during the last few years and the present year will witness many new developments of far reaching importance. Aeronautics in the short space of two decades has developed from a scientific curiosity into one of our leading industries. Airplanes constitute one of the most important adjuncts of our national defense and within the past few years their use has been extended to the transportation of passengers, mail, and freight over great distances.

The public has shown a very keen interest in flying during the past few years and many planes have been built to meet the demands of those who wish to do their own flying. These planes are sold at a reasonable price and their production should be increased this year. The Travel Air and the Pitcairn machines are the most notable of this type.

Figure 2 is a view of the Pitcairn Orowing, a two or three place light plane. It is powered with the familiar Curtiss OX-5 engine. The plane is built of welded steel tubing and is very well constructed throughout. Figure 1 shows the wing construction of the Orowing. The wing is built in a very conventional manner but is of interest as it shows typical wood wing construction. Figure 3 is the Douglas Transport which was built by a Technology graduate for the Army.

Figure 4 is the Fokker Tri-motor Transport. This plane has made an enviable record during the past year on commercial air lines. Three of these planes were flown all summer from Philadelphia to Washington for the Sesqui-Centennial.

This plane is powered with three Wright Whirlwind engines and can fly successfully on any two engines. The plane is designed with double controls and two pilots are normally carried.

Figure 5 is another interesting design and is unique in many respects. This plane can take off from either land or water, and has an excellent performance while in the air. This particular model of the Loening Amphibian is equipped with an inverted Liberty engine and a four-bladed steel propeller. Later models of this plane have been fitted with a three-bladed propeller, and Packard engines are now being used. Machines of this type were used on this year's Pan-American Good-Will flight, and were used last year by the geological survey in making maps of Alaska. The hull is built of wood and dural and contains the necessary mechanism for retracing the wheels when landing on water.

Figure 6 is the Cyclops Bomber built by the Keystone Aircraft Corporation. This plane is the largest singled engine bomber ever constructed in this country. It is powered with a Packard engine equipped with reducing gear. This plane has excellent performance and can carry a very large pay load. The Army is planning to use a great many of these ships to supplement their older Martin Bombers.

Figure 7 is the Curtis "Falcon" which is a typical observation and training plane. This view shows several details which are of great interest. The radiator is mounted beneath the engine where it can receive the air from the slip stream of the propeller. This type of radiator mounting is technically known as the "tunnel mounting," and is being widely used on all types of water cooled planes. One should also notice the long air speed indicator extending out past the propeller.

Figure 8 is the Vought "Corsair" a two place observation fighter which is being used by the Navy. This plane is equipped with either the Pratt & Whitney Wasp or the Wright Whirlwind engine. A super-charger is used with this engine which greatly increases the maximum speed attainable. The Fuselage construction of this plane is discussed elsewhere in this issue.

Figure 9 shows the engine mounting on the Douglas 0-2. This plane is powered with a water cooled Liberty engine with a tunnel mounted radiator. The shock absorber construction is also shown in this view. It consists of layers of rubber cord, known as "shock cord" wound around two horizontal members, one of which is connected to the plane, and the other to the wheel supports.

Figure 10 shows the instrument board of this plane, and may be considered as a typical instrument panel. On the left are the two switches and ammeter for the Liberty engine. Below that are the choke and carburetor mixture control for this engine. In the central part of the board are the gas pressure, oil pressure, and motor temperature indicators. At the extreme right are the various flight indicating instruments. These consist of an air speed indicator, an altitude meter, and a bank and turn indicator. The pilot must watch all of these instruments at all times as the safety of his plane and passengers are dependent on the readings indicated. It has been reported that in certain cases the air mail pilots have actually had to guess their altitude over a landing field by an altitude meter whose smallest division was a thousand feet.

Figure 11 is the Driggs "Dart" a very small, light plane. It is powered with a Wright Moorhouse engine.

Figure 12 is a Fokker Universal which is used on the New York to Boston air mail. This machine is equipped with a Wright Whirlwind engine and has given very satisfactory results on the New York to Boston run. This is a typical Fokker Cantilever design.

Figure 13 is another view of the "Cyclops" giving one a better conception of the gigantic proportions of this machine.

It may be well to pause a moment and examine some of the research work being done on planes and engines, so that our machines of the future will be even more successful than those which we have just described.

Figure 14 shows a wing undergoing a static test. This consists of loading the wing with sand-bags until failure occurs. By so doing, we can calculate the stresses in the various members of the wing and also check the strength modulus of the materials and their joints. Static tests of this kind are performed by the Government on wings, landing gears, and completed ships. Attempts are made to find the cause of all failures and improve future designs.

Figure 15 shows an example of the engine research being done by McCook-Field for the U. S. Army Air Service. At the close of the War, we had a great many water cooled Liberty motors on hand which the Government tried to use up in its construction program during the past few years. Efforts were made to bring this engine up-to-date, and the air cooled Liberty shown in Figure 15 is a result of these researches. This engine uses a Liberty crank shaft, crank case, pumps, ignition system, generator, gears and valve operating mechanism. New cylinders and pistons were fitted as the bore had to be made smaller in order to provide space for the cooling fins on the outside of the cylinders. This engine can be used as a direct vertical or it can be inverted, which gives a great many desirable characteristics. When inverted, the thrust line of the propeller can be raised and at the same time the height of the front of the ship can be reduced, thus giving better aerodynamic characteristics.

A. K. STRICKER, JR., '29.

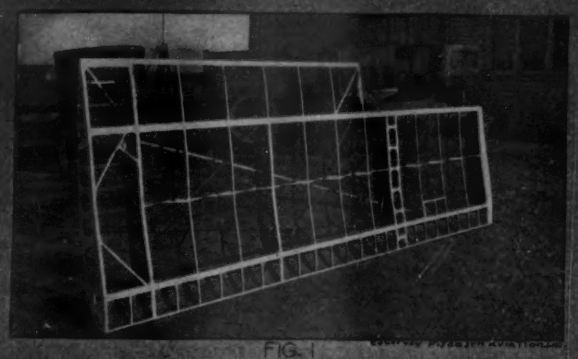


FIG. 1
WING CONSTRUCTION — PITCAIRN FLEETWING

FIG. 2
THE PITCAIRN OROWING

FIG. 3 Official Photograph U.S. Army Air Corps
DOUGLAS TRANSPORT

FIG. 4
FOKKER TRI-MOTOR TRANSPORT

FIG. 5 Official Photograph U.S. Army Air Corps
LOENING AMPHIBIAN

FIG. 6 Official Photograph U.S. Army Air Corps
"CYCLOPS" BOMBER

FIG. 7 Official Photograph U.S. Army Air Corps
CURTISS "FALCON"

FIG. 8
VOUGHT "CORSAIR"

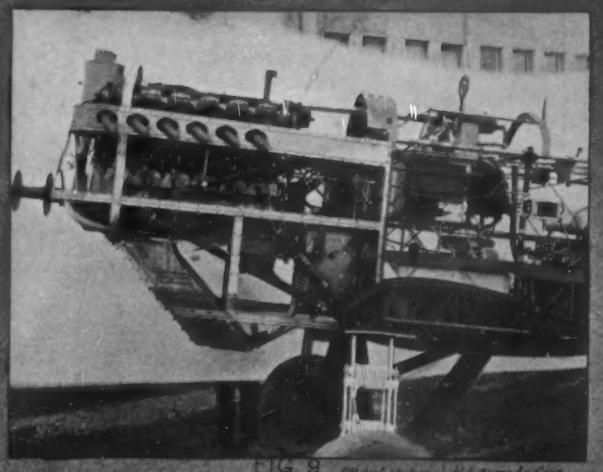


FIG. 9 Official photograph U.S. Army Air Corps
ENGINE MOUNTING DOUGLAS O-2

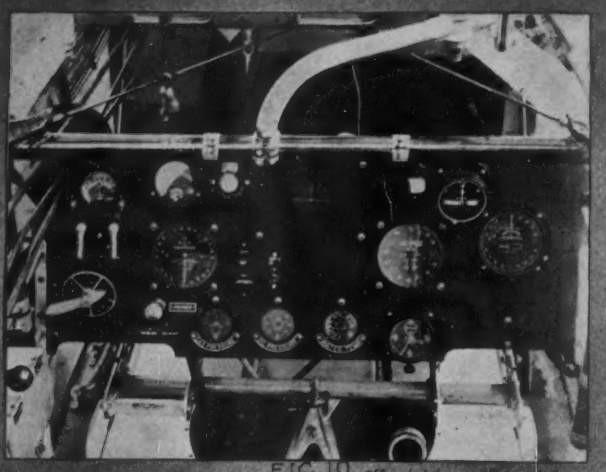


FIG. 10 Official photograph U.S. Army Air Corps
INSTRUMENT BOARD DOUGLAS O-2

FIG. 11 Official photograph U.S. Army Air Corps
BRIGGS DART

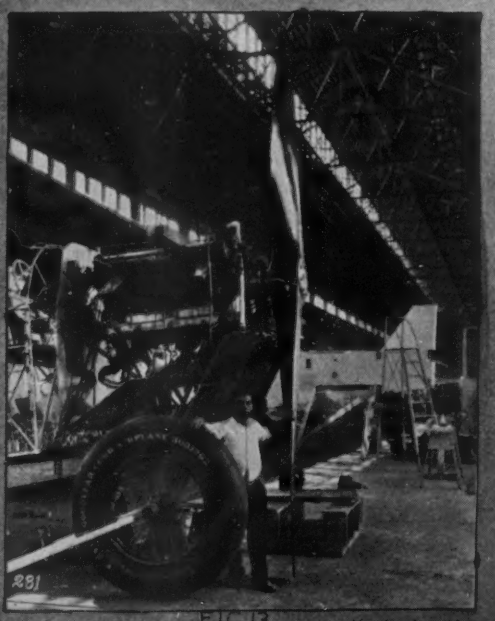


FIG. 13 Courtesy Keystone Aircraft Corp.
CYCLOPS

FIG. 12. Courtesy Atlantic Aircraft Corp.
FOKKER UNIVERSAL

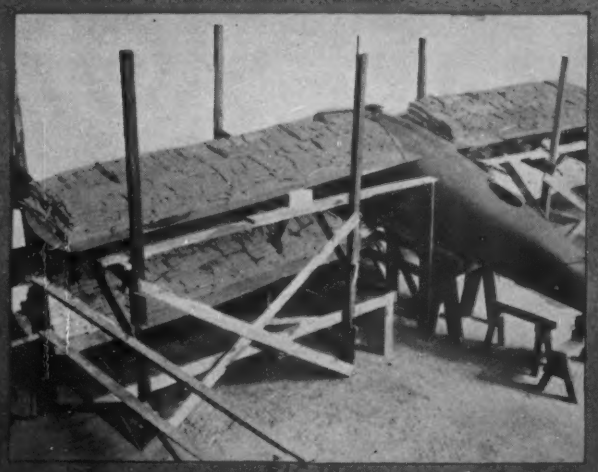
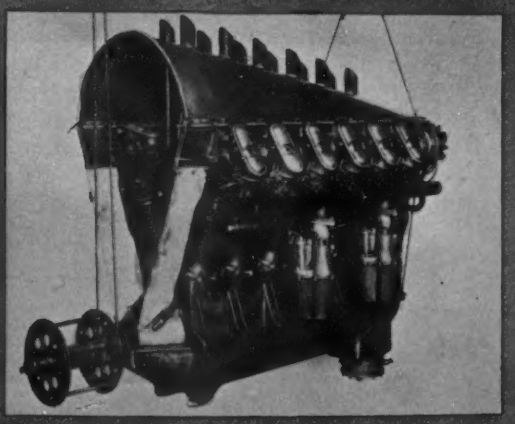


FIG. 14
WING UNDER STATIC TEST



AIR COOLED LIBERTY

Editorials

COURSE IV

The action of the Faculty in accepting the recommendation of the Committee on Undergraduate Courses to institute a five-year course in Architecture in the fall of this year is a step not to be regretted. The course in Architecture has long been one of the foremost courses offered by the Institute, and has done much to place it in its envied position among our leading scientific schools. Accordingly, when it is found that the present outline of the course does not allow sufficient time for a thorough instruction which can graduate a student whose training is adequate to the demands placed upon Technology men, an enlargement of the course is the inevitable result.

The trend toward increasing the educational requirements for a degree has long been apparent. Course VI-A, the cooperative course in Electrical Engineering, requires five years for its completion, and the opinion has been expressed that five-year courses in other subjects would be of definite value. In times past, a bachelor's degree has been considered sufficient for most engineering and scientific work, yet we find that today a growing number of students are returning for graduate work in order to meet the demand for men whose training goes beyond that received by the average graduate of a four-year course. The value of a five-year course in Architecture has been shown by its adoption in several of the other leading institutions of the land. While the additional financial burden of such a program must not be ignored, its ultimate advantages lie in its ability to turn out men who are well qualified to uphold and advance the reputation of the Institute in competition with those from other schools and to take their place in the front rank of the architects of the future.

A PLEASING PERSONALITY

One of the chief functions of a great university is to develop personality and character. Men and women entrust their sons and daughters to its guidance not alone to be filled with information but at the same time to be developed in honesty, forcefulness, courtesy, intelligence, and industry. If the proper personality is developed, knowledge will care for itself. Success is a result of two parts personality plus one part brains.

I feel therefore no hesitancy in talking about some of the interesting phases of our personalities. I am indeed delighted to have the opportunity to discuss this subject.

This discussion will be on that sort of personality which every human being would like to possess—a pleasing personality. Any man or woman who asserts that he does not like to be liked by other people is either a liar or a freak. The highest ambition of every man is to maintain the respect of those whose opinion he values. We all desire a personality that is pleasing to some other people.

But in developing a pleasing personality we have to know first of those qualities which are pleasing to other people. And here we run into a difficulty. What is pleasing to one acquaintance may not be pleasing to another. In fact, I have taken the trouble on many occasions to ask my friends to define what kind of personality is pleasing to them. They always differ in some respects: One lays stress upon good looks, another upon a sense of humor, a third upon keenness of mind. On the other hand, there are a number of traits upon which they agree.

Some of these are: How well do you like people, and how much do you enjoy talking to other people about what interests them, rather than about what interests you? The third question which may be asked is: How much sense of humor and fun do you have? A person with this sort of a disposition is admired much more than a very serious sour individual. Two more questions which can aid one in testing his personality are: How much do you do for your friends and are you a forceful, vigorous person, or are you a dead one?

If you can answer all these questions in the affirmative then you must have a pleasing personality.

THE COVER

The rendering reproduced on the cover of this month's TECH ENGINEERING NEWS is by Hugh Ferriss. The American Institute of Steel Construction, Inc., has been using renderings by Mr. Ferriss to illustrate their advertisements in architectural magazines during the last few months.

FOREST WEEK

The American Forest Week this year will be observed from April twenty-fourth to thirtieth. The problem of conservation is of as deep and far-reaching importance as any question that may present itself to the great American people. It is a problem that projects itself farther into the future than most of the questions that agitate the official mind. This question of conservation is not merely a matter of future lumber supply, great and vitally serious as that is, but it is a matter that takes in the broad sweep of the great outdoors and the preservation of the basic natural wealth upon which the greatness and prosperity of America are founded.

Indeed, the question of conservation has in it even an appeal to the heart and soul of man, because God wove into the fabric of the forest a majestic loveliness and grandeur that are incomparable. No doubt there are men who can not think in terms of beauty, but there are vast numbers of people who see something more in conservation than the protection of the money wealth which comes from the things that God put here and which man has turned to his own advantage with a selfish and prodigal hand.

It is impossible to overemphasize the importance of conservation in the matter of our future lumber supply, especially in view of the statement made by the United States Forest Service that we are using lumber four times as fast as we are growing it, and in view of the probability that the eastern half of the United States will be stripped bare of its timber, from a commercial standpoint, within the next twenty-five or thirty years, according to the present rate of consumption. When you add to this serious situation the estimate of the United States Forest Service that the tremendous supply in the Western States will probably be exhausted in thirty-five or forty years, and realize that America, the most richly blessed of any nation in the matter of forest wealth, has gone farther on the road of devastation than any nation in the history of the world and is approaching so rapidly to the exhaustion point, you may find ample cause for serious concern over the future of our lumber supply.

If you have never considered the conservation of our forests before, do so this week. Then think in terms of it and preach it so that a greater reforestation program will be initiated before it is too late.

The Engineering Field

Abstracts from the leading professional and trade journals

The Balch Project for hydro-electric development near San Joaquin, California, contains two noticeable features in that it has a very high static head of 2381 feet, and it introduces into this country the use of banded iron pipe. This pipe has been much used in Europe, and consists of a forge-welded core over which steel bands have been shrunk.

The pipe was supplied by a Polish concern, and its manufacture is quite interesting. It is 4882 feet in length, made up in twenty-foot sections. In making the sections, each one had to be individually designed for its proper place in the penstock line, and the dimensioning and spacing of the bands, the core thickness, and the type and strength of joints was determined according to the location of the particular section.

The cores of the sections are made up of longitudinal strips hammer forged together and then rolled into a cylindrical shape at an annealing heat. Consequently, it is very difficult to find the weld in the core. Steel bands were then shrunk on over the pipe, to give added strength. At the ends of the sections, the joints were machined in a lathe, as were the butt-straps fitting over them and joining the two sections together. Accordingly the work in the field became that of assembling machined fits.

The slope in which the penstock is laid has an average inclination of 45 degrees for a distance of 1100 feet, with a maximum slope of 60 degrees. To construct the line, a wooden trestle was built on the path, and the pipe laid section by section, from a gantry car on the tracks. The steep grade of the work made the construction exceedingly difficult, but in spite of this, the penstock was erected in four months. In joining the sections, single-riveted, double-riveted, and bolted joints were used. At the conclusion of the work, every bolt in the joints was tested to make sure that it was under the proper tension.

More Powerful Cathode Ray Tube —Interest in the work of Dr. W. D. Coolidge, '96, with the Cathode Ray tube has been revived lately by a recent development in that field. Because of the difficulties with positive rays bombarding the cathode at high voltages, it has been suggested that two or more tubes be "cascaded," that is to say, the rays of one tube are to be passed thru another, thus increasing both their speed and their range. Two or more tubes are placed together, so that the nickel window at the end of one tube from which the rays ordinarily immerge into the air, acts as the cathode of the next tube. The rays move with a higher velocity when they leave the first tube and when the same voltage is applied to the second tube, they are still further accelerated.

(Copyright) Electrical West.

BUILDING A PENSTOCK LINE

The steep grade, as much as 60 degrees, made necessary the use of the gantry to handle the sections.

A Heavy Oil Aero Engine operating upon the principle of the Diesel engine and using fuel injection and compression ignition is the aim of the experimental laboratories of the Sperry Gyroscope Company. The comparative fuel consumption of heavy oil and gasoline engines per horsepower is as 2 is to 3. In addition to the economy in fuel, the fire hazard is greatly reduced by the elimination of gasoline.

The method developed uses a high initial super-charging pressure combined with a two-stage expansion which continues the power impulse to the expanding gases through a larger arc of the crankshaft than is possible in engines which exhaust into the outer air. The Sperry cylinder is four times the size of the ordinary cylinder. Air is admitted from a pre-compression or supercharging pump at a pressure of forty lbs., and the fuel oil is injected shortly before the top of the stroke. A very high maximum pressure, and a mean effective pressure of 300 lbs. is thus obtained.

At the beginning of the exhaust stroke, a valve in the position of the normal four cycle exhaust valve opens, and the gases pass into a second stage cylinder, from which, at the completion of the expansion stroke, they are discharged into the air. This second-stage cylinder is mounted between two high pressure cylinders which are so timed that they exhaust alternately and the second-stage cylinder serves as an expansion chamber first for one and then for the other.

The weight reduction has been brought about by increasing the power output by the use of super-charging and two-stage expansion rather than by cutting down on the mass of the engine, as is commonly done. The difference between 80 lb. pressure in the normal Diesel engine and 300 lb. in the new type is expected to overcome the 135 lb. pressure in the average gasoline engine to a degree sufficient to make the Sperry engine adaptable to aviation use.

An aeronautical unit developing 250 h.p. is now being designed. It is expected to combine four of these in a Vee Type engine to obtain 1000 h.p.

Thick Beds of Potash have been shown to exist in Texas and New Mexico as a result of recent core drillings by the U. S. Geological Survey. Mineralogists found 10 beds aggregating nearly 30 feet in thickness, which the drill struck at depths ranging from 790 ft. to 1,760 ft. Most of the ore consisted of light colored polyhalite, sylvite and other salts containing as high as 18.5% of potassium. The beds thick enough for mining contained about 12.5%. This compares favorably with 8 to 10% obtained in the Strassfurt beds in Germany where the present supply comes from.

The Texan beds were found only after long search. Potash was suspected in that district for nearly fifteen years, for the Permian strata of western Texas is similar to the Permian strata in the Strassfurt region of Germany. In 1917 the Geological Survey made several attempts to drill for potash with little success due to unfortunate choice of sites. In 1924, however, studies of brine in oil wells in that district strengthened the belief that potash existed in Texas in commercial quantities.

A New Form of Axle Drive has been announced as the distinguishing feature of a line of trucks brought out recently. It has two rear axles, a floating live axle which carries the load, and a fixed wheel axle.

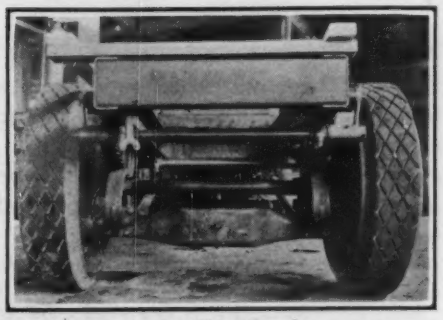
The standard truck of today has but one rear axle, which not only carries the load but also transmits the energy to the wheels. The new design, however, provides for a floating axle, which carries the load, and is placed below the wheel axle, being free to revolve about it as a center. At either end of the live axle are pinions which engage circular gear tracks on the inside of the rear wheels. Upon the application of power, this axle lifts the truck forward and upward with respect to the wheel, and the weight thus displaced acts downward to produce a rotation of the wheel about the stationary wheel axle.

To illustrate the principle, let us consider a man on the inside of a large cylinder. As the man walks up the inside surface, his weight causes the cylinder to roll ahead and the net result is to produce forward motion.

It is claimed that the new drive results in superior tractive effort, since the weight of the car is carried at a point in advance of the point of contact with the road. The floating rear axle is also supposed to have a cushioning effect which acts to eliminate jars and lengthen the life of the truck. Tire life is increased because the tires are laid on the roadbed rather than pushed against it. The truck is now being made in 2½ and 3½-ton sizes, but will later include models from 1 to 7 tons.

A New Insulation for Underground Cable has recently been developed to connect Chicago's electric generating stations. The cable, which is designed upon comparatively new principles, is to be capable of transmitting 132,000 volts. It is primarily made up of a hollow core surrounded by copper cores; then this covered with 100 layers of paper, a metal protective coating, and, over all, a lead sheath. The core is to be filled with a thin oil, under pressure. As this impregnates the paper, the insulation is of a high degree of efficiency.

The Maxim Silencer, used for muffling the report of firearms, has recently been applied to the exhaust on the oil engines of the new oil-electric locomotives. Though effectively cutting down the noise, it does not interfere with the escape of the gases into the air.



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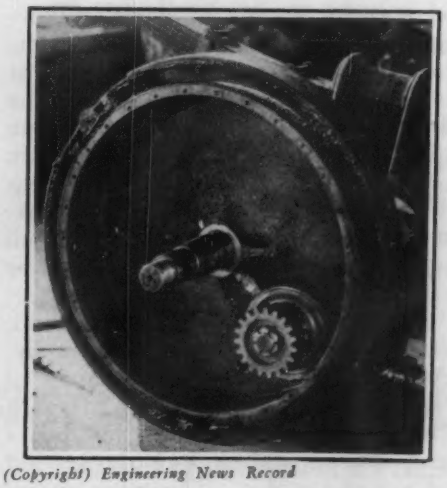
REAR VIEW OF AXLE DRIVE
The upper axle carries the load

Transparent Sheet Steel of unprecedented thinness has been made in Germany and is likely to prove of far-reaching industrial as well as scientific importance. It may be used as a membrane for the separation of gases, or lend itself admirably to the promotion of television and telephotography.

Test plates used to determine the transparency of optical glass, and which are ruled with cross lines 2,500 to the square inch, were photographed through such a metal sheet. When enlarged 400 diameter the scale lines showed distinctly, with no trace of distortion. This absence of aberration conclusively proved that the structure of the film was perfectly even and equal in all directions.

Even though the metal sheets are so thin that atoms will penetrate them without impediment, yet, when fastened in a frame, they are strong enough to be bent by blowing to the extent of 1/16 inch without rupture. The delicate sheets are made by depositing an extremely fine film of metal on a smooth surface by means of an electric current, and then separating the film from the foundation on which it is fixed.



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INSIDE OF TRUCK WHEEL
The pinion causes the rotation of the wheel by remaining stationary while the wheel turns.

An Amphibious Transmission Line was recently erected in the building of a pleasure resort near Salt Lake City. It was found necessary to set up eleven of the poles in land covered by water to a depth of from several inches to more than five feet. An additional difficulty was encountered in driving the poles through an exceedingly hard sodium sulphate strata which formed the bed of the lake. This layer was so hard that it was impossible to even drive piling through it, and the method adopted was one of combined heating and agitation. A steam jet played upon the sodium sulphate and heated it so that it was partially dissolved and dislodged, resulting in a hole about six feet deep. When the poles were set up in the holes, the loose material settled back and set up hard in a few hours, so that the poles were held in place as rigidly as if set in concrete.

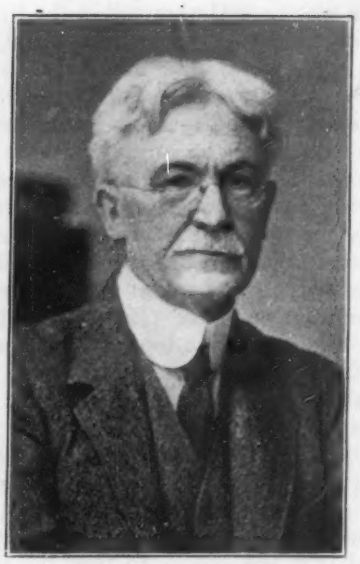
Sugar in Concrete. Recently two cases of failure of concrete to harden in Egypt, where sugar is very plentiful, led to an investigation of the effects which sugar has on the setting of concrete.

After thorough investigation it was found that sugar combines with lime to form saccharates. These destroy the resistance of the concrete in the Le Chateleir tests, and the lowering of the strength is proportional to the amount of sugar present.

Interesting cases of the failure of concrete due to sugar content came to light during the investigation. In one instance, certain portions of a building failed to set and a sugar content of 2 per cent was found in the cement. It was discovered that this sugar came from the bags which had been filled with sugar before being used for cement.

Prospecting by Airplane for copper has recently been tried in the new Katanga copper belt of Northern Rhodesia. Due to the fact that the copper salts kill all surrounding vegetation, it is possible to find them more easily by this new method—that of simply looking for bare spots in the woods. In actual practice, the territory is not only scanned by the aviator but the continuous film method for taking aerial maps is used. When a likely looking spot is found it is revisited by a geologist and more careful surveys made. It is estimated that an aviator and a capable geologist can cover about 1300 times as much territory as the ordinary prospector.

Departmental Notes



PROFESSOR D. R. DEWEY

DEPARTMENT OF ECONOMICS

Among its undertakings in the past year, the teaching staff in Business Management of the Department of Economics, has been carrying on an investigation of the organization and operation of small businesses.

An increasing number of requests for advice by graduates who wished to set up enterprises of their own gave rise to the idea that there might be some basic rules of action governing such an undertaking. No exhaustive studies of the subject have ever been made, and what little has been written is based on either personal experiences or opinions. Consequently the material can be used only with the greatest discretion.

With the idea then in mind of setting up principles of procedure which could safely be suggested for guidance to a person organizing a business, because they had proved satisfactory in many other cases, the study of this subject was incorporated in the work of the final term of Business Management. The work was first carried on by the men in the class of 1926, and the results obtained proved conclusively the value of the research.

During this first period of study, data were gathered in three ways. Lectures were given by a number of men who had personal experiences with small enterprises. The class was divided into groups of four students each, and each group submitted a report on the series of lectures, the purpose of these reports being to bring out methods of procedure which had been commonly used by the speakers when getting their respective undertakings in operation.

A second means of obtaining material was from individual reports on a textbook covering some phases of the same subject. These results, however, did not prove useful, as the data were not specific enough to be combined with any others.

The third method was through interviews with men operating small enterprises in and around Cambridge. Each group of four students was assigned a company, and two visits were made to the chief administrative official for the purpose of discussing the various methods of organization and operation employed. Sets of papers suggesting the topics to be taken up during the course of these interviews had been previously given out, and consequently the reports made by the groups contained information in such form that general conclusions could be readily drawn.

From the data gathered in these various ways by the members of the class, a preliminary group of conclusions was derived. This résumé demonstrated the value of the study, and it was decided to continue the investigation during the summer, with a departmental assistant devoting his full time to it.

The work carried on during this period was of several different types. The first task undertaken was that of interviewing all the men visited by the students the previous term. This was done to insure the validity of the material obtained before using it in the final analysis.

Then, a mailing list of Technology graduates who have had the type of experience desired was compiled. To these men, requests for coöperation were sent, and if the men evinced a willingness to help, questionnaires were sent to them. The first one covered the organization of small enterprises, and the second, which was mailed some months later than the first, dealt with the operation. These questionnaires were carefully drawn up by Professor Schell with the help of the other professors in the department, and covered all phases of small undertakings which would have to be considered by a person interested.

A third part of this summer work was the compilation of a bibliography. An exhaustive search was made of both the Technology and Harvard Business School libraries for books and articles dealing with the subject or any phase of it. This work uncovered a few valuable sources of information, but subsequently proved that the most conclusive data are yet to be obtained and published.

These various undertakings carried on during the summer are being contiued at the present time. Also, the present senior class will soon take up the particular phase of the study allotted to it, which will be practically of the same type handled by the class last year. Before the school term ends, it is hoped that all data will be complete so that a final report can be prepared on the subject. Then, as each successive class continues the research, new material will be added, and the conclusions altered to meet the trend of business conditions.

PROFESSOR W. LINDGREN

RESEARCH ACTIVITIES IN THE DEPARTMENT OF GEOLOGY

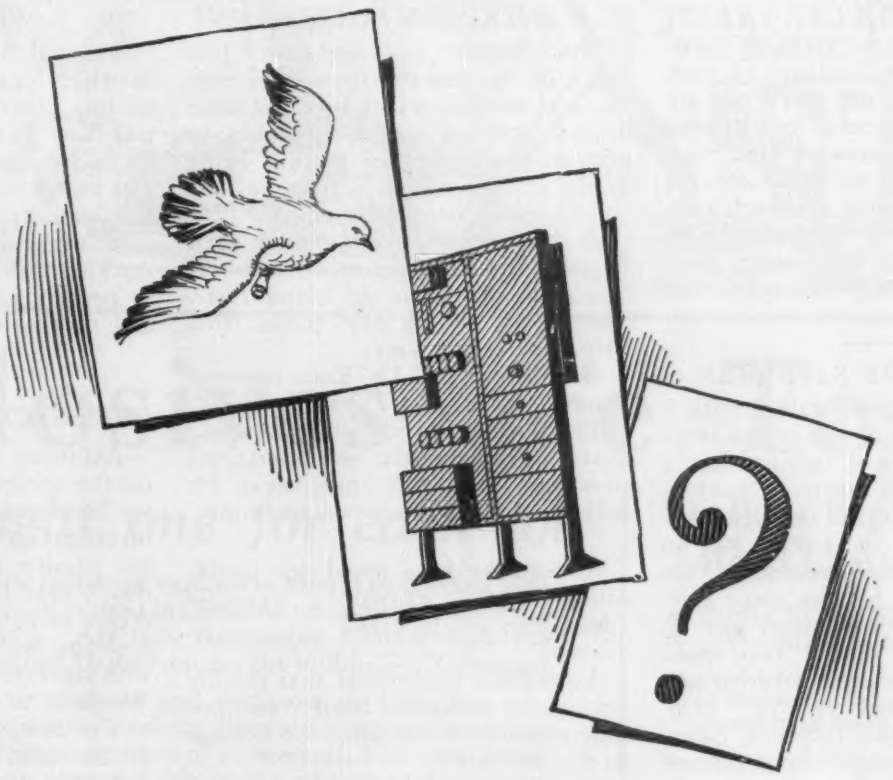
At the present time research problems are, next to teaching, the most important thing in the Department of Geology, and it may be said that for the size of the Department there is a very large amount of research work in geology proceeding, all of which will sooner or later be published in the scientific journals.

Professor Lindgren is occupied in revising his book on "Mineral Deposits" as it is nine years since the last edition appeared; he is also working on problems related to the tin-silver ores in Bolivia.

Professor Shimer is occupied in writing a book on evolution, and also is studying the Pleistocene lake deposits of the South Shore.

The investigation of contact metamorphism at Pioche, Nevada, occupies a part of Professor Gillson's time; while Dr. Newhouse is working on the succession of ore minerals and

(Continued on page 148)



Carrier pigeon to carrier current
—and then some!

IN the field of communication great strides have been taken—and greater will be taken. And just as the carrier current in telephony is an infinitely better vehicle for communication than the carrier pigeon, so new and greater developments lie ahead.

Today, as never before, this field offers an opportunity for constructive work in design, purchasing, manufacture, finance, distribution and other phases. In short, a many-sided field of work in which the ultimate horizon still lies far beyond any present view.

Published for the Communication Industry by

Western Electric Company

Makers of the Nation's Telephones

Number 67 of a Series

Here and There

Humorous notes from the Editor's desk

WHEN DID THEY GET THERE?

Railroad Engineers certainly must have had a super-abundance of good judgment in the early days of railroading, and collisions must have been unknown in Kansas. That State at one time passed a bill which ordered that "when two trains approach each other at a crossing, they shall both come to a full stop, and neither shall start up again until the other has gone."

THESE WINDY SALESMEN

A Research Engineer talked with a technical salesman of one of the large Electrical Companies asking for a three speed electric fan to be used as a part of a laboratory apparatus.

When the fan arrived there was no speed control. On questioning the salesman, he said he was sorry they did not have a three speed fan in stock, but he had sent a two speed fan. "What do you mean two speed, the fan has no speed control?" "Oh, yes it has," said the Technical Salesman, "It has two speeds—one off and one on."

BABY-TALK

Without making public our degree of sincerity on the subject, we offer the following slogan pertaining to the conservation of our natural gas resources. "What this country needs is fewer babies." Such a harrowing conclusion was drawn while reading the following is the *Gas Age Record*:

"This advice is passed along from Valdosta, Georgia, and strangely enough, is given by a bachelor W. D. McArthur, chief clerk of the gas company in that city.

"Mac has discovered that increases in family and in gas bills usually go together. With each addition to a family's responsibilities, there is immediately an increase in the use of gas particularly in water-heating, laundering, etc. This fact is not always recognized at once by the proud parents, but our hero who notes all the birth items in the faithful old *Valdosta Times,* is prepared when the irate father comes in and complains about his higher gas bill. McArthur carefully explains the difference babies make. At the same time, of course, he offers congratulations, and the would be complainant invariably becomes a satisfied customer," and another problem for those who worry about the conservation of our natural gas supply.

NEW MILK SHAKING MACHINE

The "butter and egg man" just won't let his research personnel rest. His first scheme to reap in a few more dollars was to egg on the hens to greater production by putting lights in the chicken coops. Now he has had the scientists in his employ turn their attention to the cow and the goat. Below is the latest report of their success as found in our old friend *Time*. The report, by the way, comes from Leipzig—not the West:

"Dr. Nebert and Dr. Koch reported that they had gone from stable to stable, playing music to the cows and goats. The animals so entertained produced more milk than usual, for milk yielding is a nervous reaction."

At least we have found one justification in the journalistic game:—"dead men tell no tales."

A pessimist remembers that the lily belongs to the onion family, an optimist remembers that an onion belongs to the lily family.

By the time we have reached our sophomore year, there is no doubt in our minds that we will never graduate without the three graces, Faith, Hope, and Calculus.

It looks as if the communication engineers have an insurmountable problem in transmitting a clear photograph over the continent by air as long as it must pass Pittsburgh.

CLAM POWER

Once in awhile we happen upon a good fish story. This time a school of clams takes the leading role in holding up operations at one of the power plants of the Edison Electric Light Company for a quite considerable length of time. The story needs no decoration. The condensers of the plant are cooled by water pumped from the sea thru an eight foot pipe. At the end of it is a screen for the purpose of preventing railroad ties and whales from entering our houses thru the electric light socket. After awhile no water came through the pipe. Upon investigation it was discovered that the end of the pipe was covered with a vast blanket of clams. Several methods have been tried in keeping the clams away from the Power Station, but none have been totally successful to date.

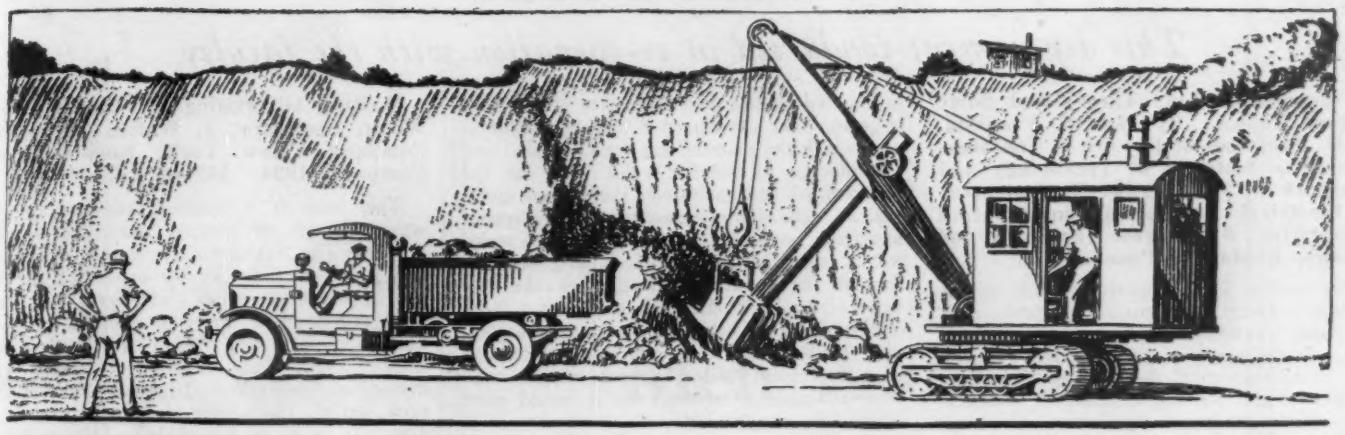
WARM ICE

Although, the last place in the world in which one could expect to find a heating plant is an ice house, a Central New York Gas Company recently sold a thermostatically controlled gas heater to one. The reason for this seeming inconsistency lies in the fact that the temperature in the stacking room must not get so low as to permit the cakes freezing together and making extraction impossible.

OUR PSYCHIC INVESTIGATIONS

Assuming an attitude of skepticism on the subject of psychic phenomena, we have conducted our own unofficial investigation of the subject. With the passing of Houdini, we have no doubt that there will be a great increase in enthusiasm and professional mediums will produce materializations with increased relish and permanence. We point to our own experiments.

The method which was employed as the most direct and least painful was this: to attend a public seance, and there to personally try to establish connections. They don't turn off the lights at public seances; that is, at nice ones. So one of these was entered, trick question left on a slip of paper, as required, at the door, and the customary hymns sung, short sermon preached by the medium, the medium's going into a trance gone through with, and a few of the questions answered without the medium's looking at them. Five such seances were attended before any of our questions were considered. All five questions were written on heavy opaque paper, and the questions were such that a vague answer was impossible. Being rather disappointed, a little more rope was allowed to the spirits, in writing heavily on rather flimsy paper. The sixth question asked of the skeptic's dead grandmother was "Will I succeed in my chosen line if I continue working hard". Results were had this time. After all the customary trouble of "tuning in of the spirit" was accomplished, the sitter was told "Your grandmother assures you that you will". What could be simpler. The medium never could have seen through the thin paper, and who other than a spirit could tell us that we could succeed if we kept working hard? Of course we are convinced!



Explosives are Tools

Use the right one for each job

WHEN constructing highways, explosives should be selected with the same foresight as is used in choosing equipment to meet the contract's requirements. Are you thoroughly familiar with the special explosives designed by du Pont for the building of highways?

For quick reference by students and engineers, du Pont has prepared a most comprehensive, carefully illustrated, compactly written handbook on the selection and use of explosives. The experiences of du Pont engineers in various fields over a century and a quarter are summed up in the Blasters' Handbook. Valuable information arranged in charts and tables. Coat-pocket size, bound in boards, 200 pages of practical, everyday help for students and engineers.

Write today for your FREE copy of the "Blasters' Handbook."

E. I. DU PONT DE NEMOURS & CO., Inc.
Explosives Department: **Wilmington, Delaware**

Du Pont Explosives for Road Construction

1 RED CROSS EXTRA
Strength—20 to 60%
—will not freeze in weather permitting road building;
—will stand water for a short time.

2 GELATIN
Strength—20 to 90%
Du Pont—25 to 90 strengths
—water-proof;
—plastic;
—practically non-freezing;
—least volume of noxious fumes.

Quarry Gelatin—*25 to 75%* strengths
—recommended for open work where shattering is required;
—not adapted to underground work.

Blasting Gelatin
—the strongest and quickest explosives known;
—absolutely water-proof;
—NOT low-freezing.

3 DU PONT STRAIGHT DYNAMITE
Strength—15 to 60%
—quick, shattering action;
—more sensitive than other dynamites;
—practically non-freezing;
—resists water.

Recent Books

This department conducted in co-operation with the faculty

Transmission Line Theory and Some Related Topics. By Wm. S. Franklin, Sc. D., Professor of Physics in The Massachusetts Institute of Technology and Frederick E. Terman, Sc. D., Instructor in Electrical Engineering in Stanford University. 312 pages. Franklin and Charles, Lancaster, Penna.

The authors have prepared a book on the physics of electric transmission, including both the power transmission and the communication field. As the previous work of Prof. Franklin has led us to expect, the new work contains many new and striking methods of presentation. With the proper application, the book can be read by a student who has had nothing of alternating current theory, provided that he has the elementary principles of calculus and differential equations well in hand. Yet the work is by no means an elementary one on transmission, treating as it does both the transient and steady state on lines, power circle diagrams and stability, and the design of artificial lines and wave filters.

The sequence of subjects is radically different from that usually followed, with the object of making clearer the physical concept of the student. The first chapter contains about fifty pages devoted to the transient state on a hypothetical line of zero losses, with a short qualitative discussion of the effect of the losses on attenuation and distortion at the end of the chapter. A short chapter on harmonic waves on the resistanceless line follows, and after this the analysis of the current and voltage conditions in the steady state on an actual line having distributed inductance, capacitance, resistance and leakance.

In Chapter IV the authors devote twenty-five pages to the constant-voltage circle diagrams of current and power, including a discussion of the Bush and Booth diagram and its use in the study of stability.

A study of Artificial lines and wave filters, applicable chiefly to communication circuits, is taken up in Chapter V. After a discussion of the characteristics of the ideal resistanceless filter, the effect of resistance is considered and instructions given for the design of low-pass, band-pass, and high-pass filters. These five chapters complete Part I, and Part II consists of two chapters devoted to Fourier's series and to non-harmonic alternating electromotive forces and currents.

Part III is a collection of seven appendices, covering principles whose complete discussion in the body of the text would impair the continuity and articulation. The inductance and capacitance of lines, the complex quantity method in alternating current theory, transients in circuits containing lumped inductance and capacitance, use of charts of hyperbolic functions, corona and inductive interference form the subject matter of these appendices.

Taken as a whole, the new book is an extremely readable text on transmission principles, and should prove a valuable addition to the literature of advanced electrical physics.

Physico-Chemical Methods, by Joseph Reilly, William Norman Rae, and Thomas Sherlock Wheeler. 719 pages. D. Van Nostrand Co. $8.00 net.

In writing this book, the authors have drawn mainly on their experience in British industrial laboratories, which has enabled them to collect information concerning most of the known methods of measurements employed in chemical and physical chemical research.

The field covered is not large, comparatively, but within this field the utility of the book is great. The customary British thoroughness with which the material has been collected and presented is of peculiar value here, for the classification and analysis of the various methods, as well as the inclusion of many special methods, saves the user much time which would otherwise be wasted in long searches through the literature. Herein lies the real value of the book; that only too often a series of experiments is held up because some unforeseen difficulty has made the common method of measurement useless whereas if the book were available a reference to it would most likely solve the problem.

Elementary Mechanism. By A. T. Woods and A. W. Stahl. (Revised and rewritten by P. K. Slaymaker, New York; D. Van Nostrand Co., 1926. 250 pp. and 248 figs.)

The number of texts, variously titled as Mechanism or Kinematics, available for the use of students and engineers is comparatively large. It is well that this is so as a thorough understanding of the principles of pure mechanism is necessary for the engineer be he engaged in the designing, producing, installing, or operating of machinery. From the early works of Reuleaux and Rankine to those of the present day the subject matter covered has been, necessarily, essentially the same.

The text which forms the subject of this review is a revision of an earlier one first published forty-one years ago. The authors have adhered very closely to the idea of preparing a purely kinematic text. No mention is made of the forces acting, even in the cases of such mechanisms as the screw, toggle, and block and tackle, as is the case in many texts on mechanism. In fact the word "force" does not appear on any page. No attempt is made to introduce even the elementary problems in dynamics.

After introductory chapters covering elementary propositions and a discussion of velocities and instantaneous centers, the remainder of the book groups mechanisms by classes depending upon the method of communicating motion. These include linkwork, wrapping connectors and direct contact, both rolling and sliding. This classification separates the elliptic gears from their equivalent mechanism, the anti-parallel crank linkage, and such similar aggregate combinations as the differential pulley and epicyclic gears. In the chapter on linkwork we should like to have seen the very close relationship between the various mechanisms developed from the four-bar linkage more clearly brought out. Every effort should be made to impress upon the student that many mechanisms differing in size, shape and member fixed are derived from the same linkage and are fundamentally the same. Otherwise he comes to think of the subject as a collection of a large number of unrelated problems.

Transmission of motion by sliding contact is logically developed with the involute system of gearing presented first as it should be due to its very wide use in practical gear trains, and because it is easier for the student to grasp. The general case of plate cam design is well presented but no mention is made of cylindrical cams or their design. However, if a text is to be kept within reasonable size as a text and not become a bulky reference, an author must of necessity omit discussions of the less essential portions of the subject. Instructors will find this a very usable text for classes in Mechanism. G. W. Swett

Writing Advertising. By James Davis Woolf, Secretary, J. Walter Thompson Company. New York: Ronald Press Company, 1926. 287 pp. Illustrated.

This book is a welcome addition to the scant amount of written treatment of the science. The author's style has a directness and snap which betray his experience in the line of which he writes. He has had, too, long experience in training men to produce advertisements, and upon the conclusions drawn from that viewpoint fashions the method of presentation of his material, yet the book has no appearance of being a classroom text. It is devoted entirely to the problem of creative copy writing, and treats the many problems met in this field with a mature and experienced judgment. The author considers not alone printed words, but illustration, arrangement and typographical makeup as well.

The many chapters are all short, but to the point and very effective. The first six prepare the supposed embryo copy writer by discussion of such subjects as "Keeping up with Changing Trends," "Getting Ready for Advertising," and "To Whom Are We Advertising?", Then the next twelve chapters deal directly with the copy itself, starting with "The Core Idea," then such as "Elements of Persuasion" and finally "Elements of Copy Style" and "Long Versus Short Copy." The last ten chapters deal with more or less unrelated problems of a general nature which the copy writer must always be able to solve and the discussion of the relative importance of the parts of the copy make-up. In this set of chapters come "The Part that Pictures Play," "The Small Advertisement," "On Getting Action" and "Practical Tests." Throughout the volume illustrations are constantly used to drive home the points made. Reproductions of advertisements are used as illustrations and serve their purpose well. The style of the author is a good illustration of how to put across or sell an idea to a reader with snap and nerve, and so well succeeds in selling his viewpoint and idea of system to the student, that he does not have to be and never is at all dogmatic.

Applied X-Rays. By George L. Clark, Ph.D., Assistant Professor of Applied Chemical Research, Massachusetts Institute of Technology. McGraw-Hill Co., N. Y. 255 pp.

In Part I the theory of X-ray science is briefly taken up and the apparatus necessary for practical research described. Part II explains the effects and application of X-radiation, a short description of the various industrial and biological methods being given. Part III is given up to the study of the ultimate structures of materials by X-ray analysis, the methods of study of Crystal Structure being described in detail.

This book fills a real need for a practical treatise, scientifically written but sufficiently understandable to the layman. The increasing use of X-rays in scientific laboratories for the solution of problems of a practical nature should be brought to the attention of the industrialist and it is felt that Prof. Clark has done a work of real benefit in his presentation of this comparatively new tool. The publishers are to be highly commended for the splendid mechanics of the book including the use of a high finish paper which enables excellent reproduction of X-ray diffraction photographs.

Men Wanted

OVER the door of America's largest commercial and industrial organizations is a permanent legend—Men Wanted.

The modern business organization, realizing its surest and sanest method of progress rests in excellence of man power, places much emphasis on the selection of its personnel.

Thousands of men are drawn each year from the senior classes; in fact, the University is the American Man Market.

Ingersoll-Rand Company offers splendid opportunities to those interested in the research, manufacture, or sale of pneumatic machinery, internal combustion engines, pumps, and steam condensing plants.

Ingersoll-Rand
11 Broadway, New York City

Fuselage Construction for Airplanes

(Continued from page 122)

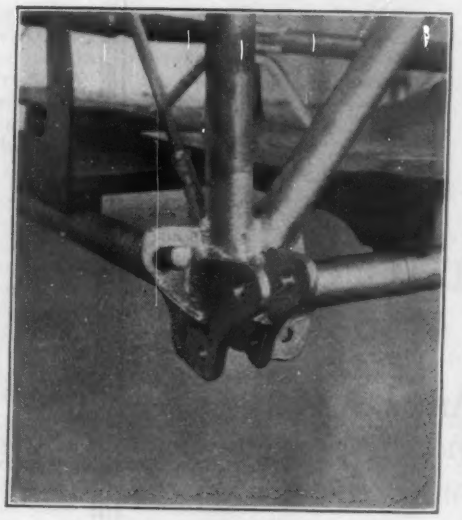


FIG. III. AN IMPORTANT STATION POINT

this multiplicity of members the detail of the joint works out rather simply by taking advantage of the opportunity of utilizing welds to join the members together. By careful design the weight of the frame, including the engine mount, has been kept down to 153 pounds, which is about 10 per cent less than an equivalent wooden stick and wire frame-work would weigh.

We may now proceed to consider the relative advantages and shortcomings of the two types of construction. Of primary importance is the question of safety to the pilot and passengers both in the air and when landing. In forced landings and crashes the metal fuselage shows up to advantage as it offers a maximum of protection to the occupants in that the structure is rarely completely demolished; the shock of impact is taken up by deforming individual members and the shape of the frame is usually well maintained. Numerous instances are on record of crashes of planes in which the landing gear was wiped out completely without injury to the personnel and comparatively little damage to the steel framing. A well designed stick and wire fuselage will also withstand severe landing shocks but in a complete crack-up there is danger of a strut or longeron breaking off and piercing the occupant of a cockpit.

To compare the relative safety of both types in the air one must necessarily assume that both have been properly designed and are adequately strong when first completed. Safety then becomes a question of ability to maintain the structure in good condition and to recognize when it is deteriorating to such an extent as to make further flying inadvisable. This is a controversial point but the wooden structure seems to have the advantage. The writer recently had occasion to examine a UO-1 fuselage which had seen eighteen months of strenuous service in a Naval Reserve Training Unit and was undergoing its first overhaul. The airplane had had a total of 655 flying hours. The fuselage structure was completely disassembled, all fittings removed, and the finish scraped from the wooden members, all of which were found to be in good condition. The fuselage was reassembled without it being necessary to supply any new parts. It is not possible to make so perfect an examination of the usual metal structure whose members are ordinarily closed sections. Such a structure can be inspected for evidence of external corrosion, incipient cracks, etc., but there is no way of determining whether or not corrosion is taking place inside the members.

Prevention of corrosion is a serious problem which has by no means been completely solved. Mineral oils and slushing compounds have been found to be quite effective as a means of protecting the inside of the steel tubes, but structures have been cut apart on occasions to investigate the condition of the tubes, and have been found to be severely corroded inside. The problem is particularly serious in the case of aluminum alloys because while they are of themselves more resistant to corrosion than is unprotected steel, yet when corrosion once starts they go to pieces very rapidly. In addition, they are also subject, under certain conditions, to a type of corrosion which is termed "inter-crystalline" corrosion. This results in the formation of cracks which extend into the metal reducing its strength and ductility. The worst feature is that it may produce no change in the appearance of the surface which is visible to the naked eye and there is danger of the deterioration being quite well advanced without being detected. Intensive researches are being conducted in this field by the Navy Department and the Bureau of Standards and encouraging results have been obtained, but until the effectiveness of proposed protective treatments has been thoroughly demonstrated by tests of experimental airplanes operated under service conditions one may seriously question the prudence of using aluminum alloys in the primary structure of the fuselages of seaplanes where corrosion is accelerated by the presence of salt water.

(Continued on page 140)

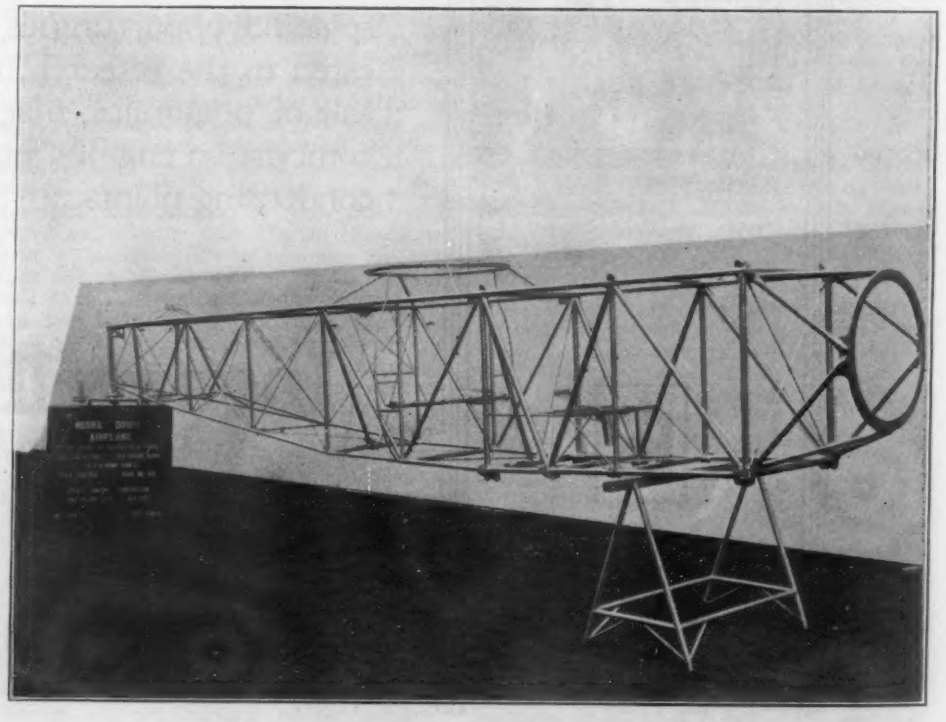


FIG. II. FUSELAGE ASSEMBLY OF VOUGHT "CORSAIR"

The cut shows an "Ironclad" cutting up a steep pitch in a colliery near Charleroi, Belgium. The seam is 22 inches thick and the pitch 25 degrees. The working face is 300 feet long. Production was almost doubled by the introduction of this machine.

Mining the World's Coal

Sullivan Engineers perform many services for the coal mining industry—

Coal lands are tested by Diamond Core Drills, to show the depth and character of the seams.

Shafts are sunk or slopes driven with Sullivan Air Drills, run by Sullivan Compressors.

Entries are driven, the seam cut and sheared, with Sullivan Ironclad Coal Cutters of several types, to suit many conditions.

Rock is removed underground and the coal drilled for shooting, with Sullivan Mine Car Air Compressors and Rotator Drills.

Sullivan Bit Sharpening Machines and Portable Hoists perform other tasks. There is, in fact, no industry served as broadly by Sullivan Equipment and Sullivan Engineers as is coal mining.

Sullivan Coal Mining Equipment is known and used wherever coal is produced—in Great Britain, in France and Belgium and Spain, and Poland and Russia; in India and South Africa and Australia and Japan, in Chile and Venezuela and Mexico, and in every Coal State in the Union.

The excellence of Sullivan Engineering and the efficiency of Sullivan Equipment are constantly winning new markets the world over.

Many engineering graduates are finding their opportunities for growth and advancement, in helping this company to solve the problems which arise in mechanizing the mining of coal.

The Sullivan Machinery Company has a limited number of opportunities for engineering graduates in its sales department. Its field includes not merely coal and metal mining, but engineering construction, road building, the petroleum industry, water supply, and manufacturing, wherever compressed air is used.

If you are interested, write at once for the booklet, "Engineering Opportunities with the Sullivan Machinery Company."

COMPRESSORS · AIR LIFT · COAL CUTTERS · DIAMOND CORE DRILLS · ROCK DRILLS
PORTABLE HOISTS · DRILL SHARPENERS AND FURNACES · BUSTERS · SPADERS

SULLIVAN TRADE MARK

MACHINERY COMPANY

NEW YORK LONDON PARIS TOKYO SYDNEY

164 South Michigan Ave., Chicago, Illinois, U. S. A.

Open House Night

(Continued from page 123)

Francis '28

FIG. III. FOUNDRY LABORATORY POURING IRON

This is part of The Foundry Laboratory which accommodates a class of 100 students, and is equipped for instruction in the principles of foundry practice and machine methods of quantity production.

lecture experiments. All necessary apparatus is set up outside on tables mounted on a complete railway system which are rolled in at the proper time and connected to the gas, electric and water mains near the center of the room. All the lights, curtains and projectors are controlled from a panel near the speaker's desk. During the day special experiments will be conducted, and movies will be shown of the students at work in outside industrial plants during the optional courses of the senior year. This room will always be available for a brief rest.

Proceeding past the physics laboratories the visitor comes to the Mining Engineering Building, where the complete process of recovering and smelting metals will be shown from the ore crushers through the smelting and refining processes to the final casting of the ingot. In Building four, experiments with very low temperatures in the refrigeration laboratory on the lower floor may be contrasted with work in the heat laboratory on the second floor. On the fourth and first floors of this building are the extensive chemical laboratories, and on the third floor a splendid collection of minerals and photographs of the world's natural wonders will be seen in the Geological Museum. In the basement is the X-ray laboratory, where all size X-ray cameras will be in operation up to the largest one for exploring the interior of metal castings. The latter machine is housed in a room the walls of which are lined with eight tons of lead. An X-ray fluorescent screen device will permit people to watch their own heart beating and the movement of their bones.

Thesis work in Industrial Chemistry will be demonstrated on the first floor of Building two, and in the basement in the outside wing of the same building, experiments in the newly applied theory of stress analysis by photoelastic methods will be under way.

Passing across the beautiful court, illuminated by indirect floodlights and a searchlight playing on the buildings from the Boston side of the river, the visitor will enter the outer wing of Building one. After calling at the Air Corps R. O. T. C. dugout in the basement to see the war trophies and airplane engines, he will come to the Business Administration department, where business charts and office appliances will be on exhibition. On the second and third floors of this building will be a complete exhibit of structures and photographs of extraordinary engineering accomplishments by the Civil Engineers. In one of their drafting rooms will be an exhibition of the student designs by the Architects, who have their own building across the river. All of these designs will be original student problems and will afford much material for a day's visit in that room alone.

The Naval Architects and Aeronautical Engineers have their headquarters in Building five. On the top floor are the extensive Marine Engineering drafting rooms. On the third floor is a large lecture room, where a continuous series of motion pictures illustrating industrial operations will be shown, affording still another chance for a brief rest. On the second floor is the Naval Architecture model cutting room, with small models actually being shaped. On the same floor the drafting room of the Aeronautical Engineers will contain a display of many student airplane designs and panels of airplane parts and fittings. On the first floor of this building is the Clark collection of marine paintings and models in the Naval Museum. This is the finest collection in New England and contains models of all the representative types of boats in the world, as well as all classes of Naval war vessels. There are many fine models of clipper ships.

Passing back into another wing of Building one, are the Testing Material Laboratories, containing huge machines for testing the strength of all kinds of engineering materials and structures in tension, compression and twisting. The largest of the machines has a capacity of a million pounds, and many others are nearly as large. Actual destructive tests will be under way. Above on the third floor is the heat treatment and microphotographic equipment.

In the next wing, the Steam and Hydraulic laboratory, the visitor will

(Continued on page 146)

United News Picture

FIG. II. DYNAMO LABORATORY, ELECTRICAL ENGINEERING DEPT.

INSULATION PROBLEMS

are properly solved only by:

First: Selecting the right type of high grade insulation to meet the special engineering conditions.

Second: Determining the proper thickness for maximum efficiency.

Third: Seeing that insulation is thoroughly applied.

Fourth: Selecting the proper protection against atmospheric conditions, external injury, etc., and by sealing the insulation.

We meet these requirements with:

First: 85% Magnesia, high temperature insulation, hair felt, and cork, or a combination of two or more of these materials.

Second: Care in balancing amount of insulation against cost and efficiency.

Third: Employing experts in all branches of the art.

Fourth: The use of Thorkote—the ideal seal and protection.

Specifications and information furnished on request

P. S. THORSEN & CO., INC.,
81 Coffey Street,
BROOKLYN, N. Y.
Tel. Henry 3081-2

P. S. THORSEN CO. OF MASS.,
43½ "L" Street,
SO. BOSTON, MASS.
Tel. So. Boston 1330

Sheet Metal Stampings

HUMIDIFIER

FOR THE

HOME *and* OFFICE

Hollow inside, large reservoir on each side, allows heated air to rise through water-soaked open weave wicks.

Perforated Cover.
Beautifully enameled in olive green.
Circular sent on request.

PETER GRAY & SONS, Inc.

Manufacturers of Sheet Metal Specialties since 1878

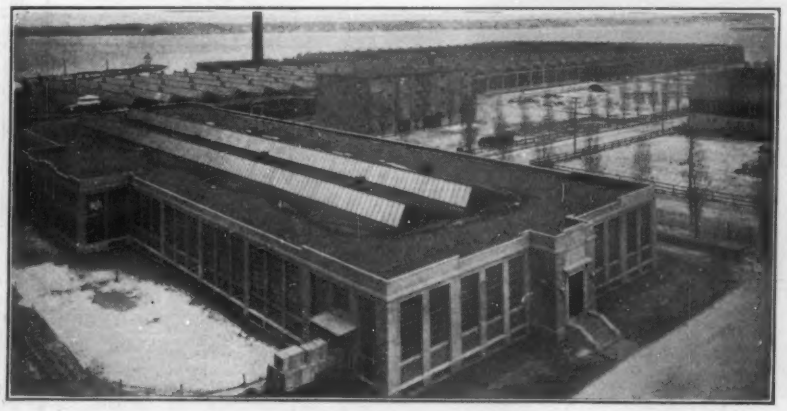
Third and Binney Streets - East Cambridge, Mass.

Fuselages

(Continued from page 136)

Maintenance and repair present another problem which is many sided. A good wooden structure has a surprisingly long life and offers the further advantage that it is often possible to replace individual members which may have been damaged without the necessity of overhauling the entire structure. A UO-1 seaplane one day made a forced landing at sea in a heavy ground swell. The pilot made a good landing on the crest of a long roller but the plane brought up an instant later against the face of the next wave and with such a shock that he felt sure the float must have been broken. The float and float-struts were, however, undamaged and when the plane was hoisted aboard ship it was found that a couple of wires had broken in the side truss of the fuselage, but the flexibility of the structure had absorbed the strain without damage to the other members. It was only necessary to install a couple of spare wires to put the plane back into flying condition. Had the structure been a welded tubular one it is probable that one or more joints would have been distorted by the failure of the diagonal and more extensive repairs would have been necessary. It has, however, been found perfectly possible and not exceedingly difficult to repair damaged members in welded structures by splicing and welding in a new member. Entire joints even may be cut out and replaced. Replacement of welded joints is more difficult than the insertion of a simple member and some designers are attempting to obtain the advantages inherent in stick and wire construction by using separate fittings welded to the longerons and riveting

(Continued on page 150)



One of the finest textile mills in the world, built by Wm. T. Reed Co. Several repeat orders have been received from this firm.

WILLIAM T. REED CO.

BUILDING CONSTRUCTION

201 DEVONSHIRE STREET, BOSTON

We are organized and equipped for the efficient handling of mercantile and industrial building construction of all descriptions.

OKONITE
OKONITE-CALLENDER
PRODUCTS

WE are well equipped to manufacture large and small single and multiple conductor cables insulated with rubber, varnished cambric or impregnated paper for any service, any commercial voltage and with any type of covering or armor.

FLEXIBLE CORDS AND CABLES
All types, all services

WIRES FOR RAILROAD SERVICES
Signals, Locomotives, Cars

POWER WIRES AND CABLES

SPLICING MATERIALS

The Okonite Company
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The Institute's Part in Aeronautics

(Continued from page 114)

McCook Field has been done in the Institute's wind tunnel.

Both for the Engineering Division and for private constructors large numbers of tests of complete models of airplanes have been made, and the Institute's work has come to be recognized as something of a standard in this respect. The tests have generally included the determination of stability, performance, and the effect of all three controls. Some work has been done in the design of tail surfaces for airships and in tests of helicopters to determine the possibility of safe descent with a dead engine. Determination has been made of airflow constants for various types of radiator cores, and research in heat transfer for use in the design of water recovery condensers for airships has been carried out. A classic series of measurements of pressure distribution over a model tail surface was made, and this work led to the very interesting full flight tests of pressure distribution made at Langley Field.

In addition to the strictly aeronautical research work an extended study was made of the aerodynamics of yacht sails both in the wind tunnel and in full scale. The results of this work had a marked effect on sail design for racing schooners. A long series of tests of airfoils previously developed and tested in other tunnels was made in order to reduce these tests to a common basis of comparison. Several new pieces of research apparatus were also developed in the wind tunnel. Among these was the six component automatic wire balance, by which three forces and three moments are measured simultaneously. A further development was the propeller dynamometer, by which torque and thrust on a model propeller can be measured. This propeller dynamometer has been installed in a quarter size model airplane in the large tunnel. Study has been made of the mutual interference between model and propeller and on the effects of slipstream on the model and on the control moments. This work constitutes a distinct forward step in aeronautical research.

In no respect is the Institute's part in aeronautics more evident than in the work of its graduates. The name of the Assistant Secretary of the Navy for Aeronautics is so well known that it has appeared in a "What Do You Know" questionnaire. It might well be mentioned at this point, however, that the Assistant Secretary for Aeronautics, although on leave of absence from the Institute, keeps closely in touch with its aeronautical work and continues to determine the policies followed. He is, however, not the only Institute graduate who is prominent in the navy department. The Assistant Chief of the Bureau of Aeronautics, Captain E. S. Land '07, the officer in charge of the Material Division at the Bureau, Captain H. C. Richardson '06, and the manager of the Naval Aircraft Factory, Captain G. C. Westervelt '08, are all graduates of the Institute. In the Army Air Corps the highest engineering position, that of chief engineer at McCook Field, has always been held by Institute graduates, and in the staff at McCook Field former students of the Institute are in charge of several important sections. Among the M. I. T. men who occupy prominent positions in the in-

(Continued on page 144)

"Of all inventions, the alphabet and the printing press alone excepted, those inventions which abridge distance have done the most for civilization".—Macauley.

The subsidiaries of the Fairchild Aviation Corporation have always been pioneers in the aëronautical industry, addressing themselves to the task of reducing the cost and increasing the utility of aëronautics. This is one contribution of Fairchild Aviation to the advance of civilization.

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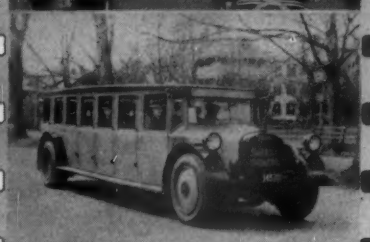

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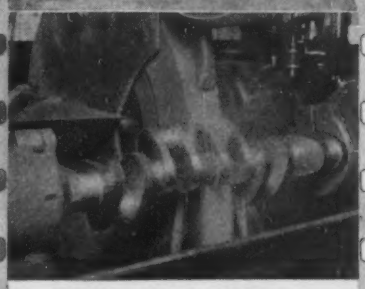

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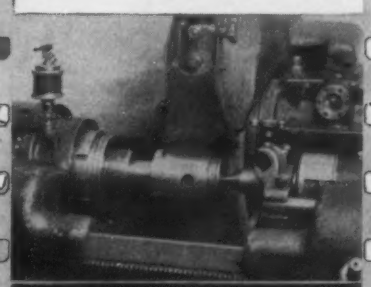

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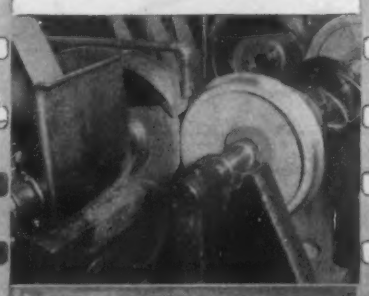

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The Institute's Part in Aeronautics

(Continued from page 142)

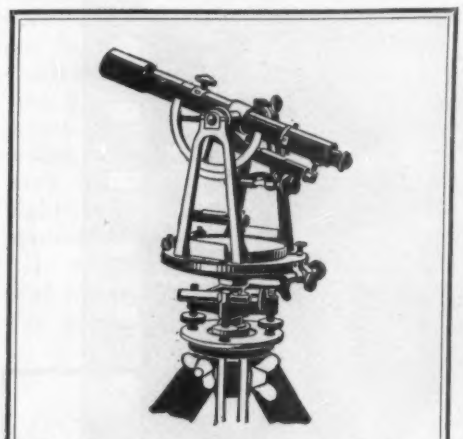
dustry may be mentioned Donald W. Douglas '14, president of the Douglas Company, George J. Mead '16, vice-president of the Pratt & Whitney Aircraft Company, T. P. Wright '18, chief engineer of the Curtiss Company, V. E. Clark '15, vice-president of the Consolidated Aircraft Corporation, C. J. McCarthy '16, executive engineer of the Chance Vought Corporation, and Elliot Daland '18 of Huff-Daland Airplanes.

The future of aeronautics at the Institute is most hopeful. Through the generous gift of the Guggenheim Foundation a new building for aeronautics is assured and will be occupied during the next academic year. The building is to be three stories high, and will measure one hundred and fifty feet by sixty feet in plan. In the basement are to be the two wind tunnels with their power plants and instrument shop, and just above will be the offices for the research staff. Half of the first floor is to be occupied by the upper part of the room for the large wind tunnel and most of the remainder will be devoted to a library and a museum. On the second floor are to be a large drafting room for undergraduates, a rigging room in which an airplane of fifty-foot span can easily be set up, several research rooms for special projects, and the headquarters of the instructing staff. On the top floor will be drafting rooms for graduate students, class rooms, more research rooms, and a testing materials laboratory.

As the building is large enough to meet the requirements apparent for several years to come, the development of aeronautics at the Institute will not be hampered by physical limitations.

Aeronautics has not in any sense reached a standardized or static condition, and it is therefore to be expected that the course in aeronautics at the Institute will continue a development which will keep it abreast of general progress. It is evident that air transport in the United States, after a long period of uncertainty, is now getting on its feet. This new development will bring new problems, and men will be required who are capable of meeting them. A course in air transport is already available for graduate students and it is likely that the future will see a considerable extension of this work. Military and naval aircraft building programs, after a period of violent fluctuation following the war, seem to have reached a state of comparative constancy. In civil aeronautics, on the other hand, the prospects for continued expansion appear excellent. Lacking the government subsidies universally granted abroad, development in commercial air transport in the United States has been comparatively slow. With the establishment of a bureau of aeronautics in the department of commerce, however, airplane navigation may now expect to receive the same aid from the government which maritime navigation has so long enjoyed, and with the extension of the air mail, commercial aeronautics in the United States may be considered assured. The great distances between many of our large cities and the absence of political frontiers which have so greatly hampered progress in Europe all point to an American development in aeronautics much more extensive than that abroad. With this greater development will come greatly enlarged opportunities for the Institute, both in training men and conducting research. The Institute is alert to discover these new opportunities and will continue to meet the obligations which they impose.

Combating Corrosion. A process for protecting aluminum from oxidation and corrosion with metallic finishes of various colors has been developed in Germany. It consists of dipping and boiling the article to be finished in baths containing solutions of copper, zinc, tin or other metals and their alloys. The effect so obtained can be further varied by polishing the aluminum before and after treatment and by applying a thin coat of wax to the finished surface. As no electric current is used in the bath, electroplating does not take place. Instead, it is claimed, that an actual "amalgamation" is effected with the surface of the aluminum.



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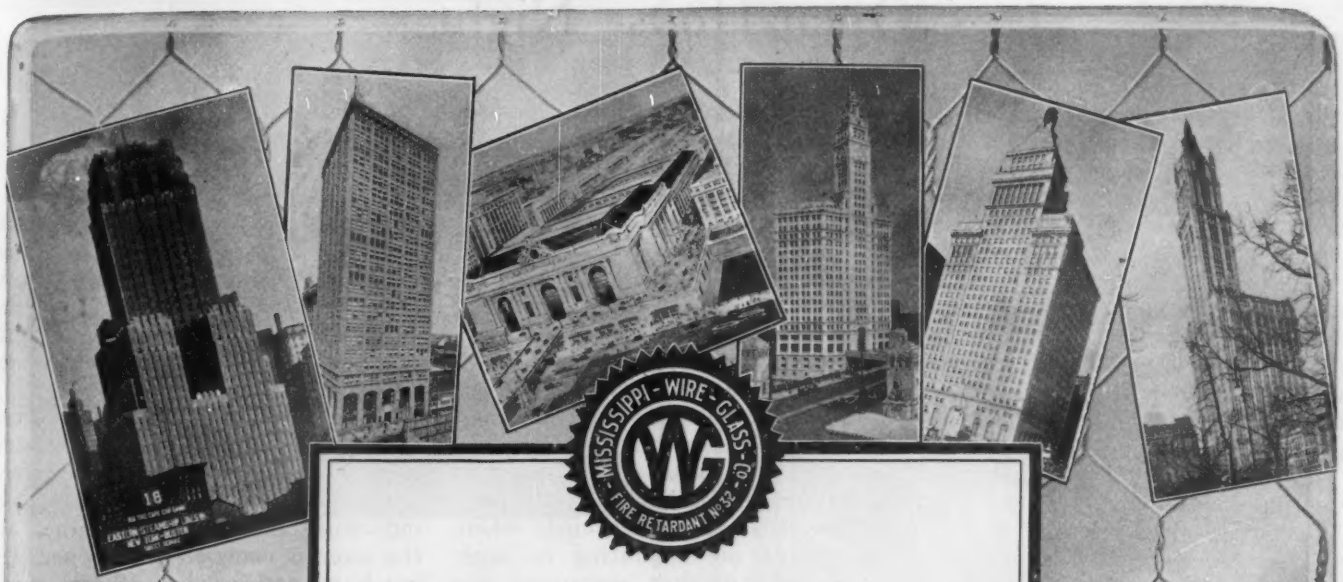

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Open House Night

(Continued from page 138)

be amazed at the size of the apparatus being used by the students. In the basement is a large steam engine driving a huge centrifugal pump that delivers water to a channel on the second floor at the rate of twenty-two thousand gallons a minute. Various irrigation and sluiceway problems can be worked out with the flow in the channel, at the end of which the water flows into a large hydraulic turbine with a forty-two foot head. The same laboratory is crowded with other steam engines, turbines, and hydraulic measuring devices.

Directly above on the third floor is the large Machine Tool laboratory, closely packed with ultra-modern machines for the shaping of metal parts. Large lathes, grinding, and milling machines will be in use, capable of working to less than a thousandth of an inch. Measuring devices capable of recording deflections of a millionth of an inch may be used by the visitors themselves. A very novel ball-bearing testing machine will be in operation. The walls of this room are lined with examples of fine machine work, and many complicated pieces of motors are cross-sectioned and cut open for inspection. Adjoining this are the Textile laboratories, and above it are the extensive drafting rooms of the Mechanical Engineering Department.

Passing by the R. O. T. C. quarters, where the various units will have displays, the visitor will again come to the Main Lobby, back of which are the Electrical laboratories. Here the most modern dynamos and measuring devices will be in use. In this laboratory the student gets experience with real commercial equipment and learns to keep it running under all conditions.

Passing outside to the detached buildings, the visitor will come first to the Aeronautical laboratory, housing the two big wind tunnels where experiments are conducted on scale models of airplanes measuring the forces the air exerts with automatic recording balances actuated by wires from the model in the tunnel. The largest of these tunnels is eighty feet long, with a seven-and-a-half-foot throat section and the finest recording instruments of any educational tunnel in the world. The smaller tunnel has a four-foot throat, and from it has come many of the most important results and discoveries that have been made in American aerodynamics. In an adjoining building are housed the airplanes that are used by the class in rigging, and a class will be actively engaged in assembling a plane. Tanks and various pieces of ordnance equipment used by the R. O. T. C. are also kept here. Nearby is the Automotive laboratory where tests on automobile and airplane engines will be under way,, and where students may run tests on devices of their own.

Just a little beyond, next to Tech's big power house, is the Forge and Foundry building, perhaps the most interesting of all. On the top floor is the foundry, where many students will be at work making molds of small machine parts, showing the whole process even to the pouring of the metal casting. Machine molding will also be demonstrated. When the casting has cooled the sand will be broken away and the pieces distributed to the visitors for souvenirs. The most modern equipment is used in this laboratory and all safety precautions are taken. Just below is the Forging laboratory, where students will be engaged in making welds, and forming hooks, handles, and chains at their individual forges. These also will be distributed as souvenirs. A commercial drop forging machine will be in use. In the next room is the Pattern Making laboratory, where modern methods of rapidly cutting patterns are shown. Each student works at an individual electric driven lathe, and the room is completely equipped with bandsaws and grinding wheels.

If the visitor has not already left the main buildings for the pleasant environment of the students' own building, the Walker Memorial, he will surely do so now, and find many of the other undergraduates at the work that is their play. The entire building is devoted solely to the students, containing their organization offices, and the main eating hall, as well as the undergraduate meeting auditoriums and dancing floors. Practically the whole upper floor is devoted to a completely equipped gymnasium and locker room. The building also houses handball courts, bowling alleys, and a poolroom with periodical and fiction libraries for the sole use of the students. On the second floor is the Trophy Room, where Technology's laurels are displayed, and where, also, for the evening, will be many individual exhibitions by the various activities and organizations.

At 11:00 in the evening the Chemical Warfare Unit of the R. O. T. C. will stage a demonstration of modern warfare on the parade ground between Walker and the main buildings. Smoke bombs and tanks will cover the advance of the skirmishers, and the whole scene will be illuminated by brilliant magnesium star-shells.

F. T. Kurt, '27.

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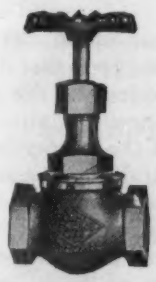

Fig. 106
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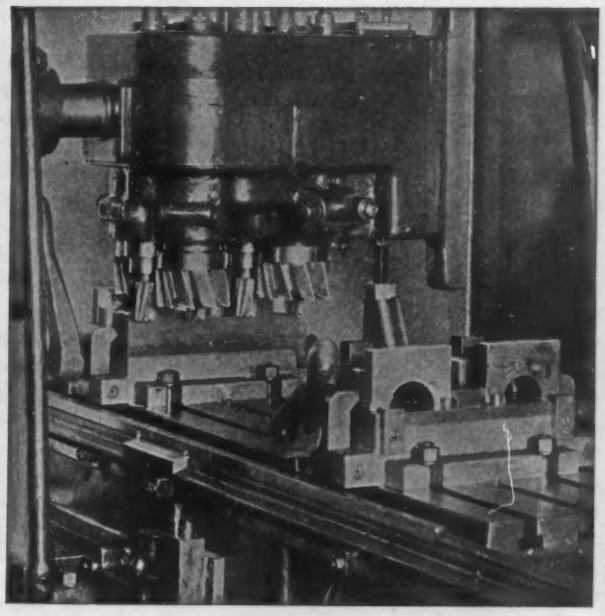

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Aero Research

(Continued from page 121)

of the model, the velocity, or the specific characteristics of the fluid.

The variable density wind tunnel is in general similar to the ordinary closed type wind tunnel, but is entirely enclosed by a large egg-shaped steel tank. This makes it possible to use compressed air of various densities as the testing fluid or medium. A two-blade forged duralumin propeller at the end of the exit cone, driven by a synchronous motor of 250 horsepower, revolving at 900 R.P.M., circulates the air, drawing it through the five-foot test section at a velocity of about fifty miles per hour. When the air pressure in the tunnel is 300 lbs. per sq. in., abs., equivalent to a density of twenty atmospheres, a Reynolds number $\frac{p\,v\,l}{u}$ of 3,600,000 is reached on a five-inch chord model. Were the velocity varied instead of the density, this value of Reynolds Number would represent a velocity of 1000 miles per hour.

Three balances inside of the tunnel weigh automatically or by manual control the forces on the model. These forces are recorded by taking observations through small peepholes in the walls of the tank. Likewise, the velocity head is observed and recorded, a large micromanometer being used for this purpose; heads of 25 to 26 inches of water are recorded on a test at 20 atmospheres density.

This wind tunnel has been in operation for a period of two and a half years, during which time a considerable number of tests have been made on airfoils, airplane models, airship models, and on airflow surveys.

In the research work, some interesting points have been brought out, chiefly in regard to scale effect on the aerodynamic characteristics of the various models. On airfoils of small camber and thickness, the scale effect is usually small, while on airfoils of large camber and thickness, the effect

(Continued on page 152)

Departmental Notes

(Continued from page 130)

on the relations of ore deposits to the various igneous rocks. Mr. Buerger has started a research on the deformation of sulphides by pressure and is also taking up the study of the lime silica bricks.

Dr. Boydell is writing on operative causes in ore deposition, and has also completed a chapter on colloidal processes in mineral deposits for Alexander's book on Colloidal Chemistry. The solubility of cassiterite, and some features of the South African gold deposits are other subjects under research.

Mr. Gunning is studying the silver-lead of the Lardeau district, British Columbia, while Mr. Smitheringale is examining an interesting copper deposit in the same region.

Paleontological research is represented by Professor Morse, who is working on the Carboniferous faunas of the Mississippi.

During the past summer Mr. Callahan was employed on the surveying staff of the Cornwall, Pennsylvania, mines, and is now preparing a paper on the origin of those iron ores.

Mr. Rexford is investigating an iron deposit in New Jersey; Mr. Meng, a silver deposit from Sumatra; Mr. Williams, the contact metamorphic rocks of Blue Hill, Maine; and Mr. Lary is busy with a pegmatite dike from the same State.

So all in all, we can conscientiously say that the Department of Geology to the best of its ability is upholding research at the Institute of Technology.

W. LINDGREN.

FUEL AND GAS ENGINEERING

One of the most important engineering operations in practically all industries is the production of heat and the generation of power. In the United States approximately 95% of this power is generated by the combustion of coal, oil and natural gas. This enormous utilization of fuel has been necessitated by the tremendous effort to increase the efficiency of industrial processes through the displacement of hand labor by the use of power driven machinery. Both the constant increase in amount of power required and the increased cost of fuel have necessitated more efficient methods of fuel utilization. Improvements have been made in not only the more obvious operations such as the combustion of coal under boilers and the use of gasoline in automotive engines, but also in the preparation of the fuels and transformation of one kind of fuel into other forms. As examples may be cited, the manufacture of smokeless fuel for household use, the processing of crude petroleum to yield products suitable for engines, house heating and lubrication and the conversion of solid into liquid fuels.

Because of the universal importance of fuel utilization the Institute has established a course in Fuel and Gas Engineering, the purpose of which is to train men in the solution of the problems incident to combustion and fuel processing. These problems are essentially of an engineering nature and therefore specialization in this field demands a thorough preliminary training. For this reason the course in Fuel and Gas Engineering has been planned as advanced graduate study for men who have completed an adequate undergraduate course in Engineering or Chemistry.

The work consists of two parts, namely, a year's class room and laboratory study of fuels at the Institute, and six months' field work at plants utilizing or processing large quantities of fuel.

The matter taken up in the class room is designed to give the student not only a broad view of the entire field of fuel utilization but also a detailed knowledge of the properties and reactions of natural and manufactured fuels, and the equipment necessary for their utilization. The fuel engineer must have, in addition to a detailed knowledge of fuels, a keen

(Continued on page 154)

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As a contribution to the cause of Industrial Education we have prepared a two-reel motion picture portraying the methods employed by explosives manufacturers and the United States Bureau of Mines in obtaining information which the engineer must have to use the various types of explosives intelligently. It also depicts the different types of projects where men trained in this branch of engineering are needed to decrease costs and increase safety.

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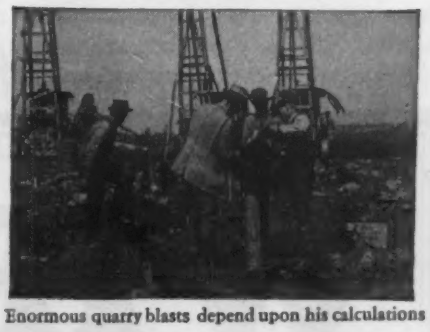

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Ancient Works

(Continued from page 119)

could not have been a straight slope leading up to one side of the pyramid. The grade had to be kept easy for practical reasons; and for a pyramid of considerable height, such as the Great Pyramid, originally 500 feet high, a straight ramp would have become absurdly extended as the pyramid rose. It has been very reasonably suggested that the ramp wound spirally around the pyramid. This suggestion seems to the writer to be supported by a statement made by Herodotus (II,125). When Herodotus visited the pyramids in the early part of the fifth century B.C. they had become already venerable with an existence of more than two thousand years, and the famous Greek traveler looked upon them with wonder and with his characteristic questioning curiosity. He was told by his guide that the casing (which made the surface of the pyramid a smooth incline from apex to base) had been put on from the top downwards. The casing blocks could most easily have been set in position during the process of removing the spiral construction ramp.

Fuselage Construction

(Continued from page 140)

or bolting the struts thereto. This practice, however, increases the cost of building the fuselage and is only a partial solution as, if a failure should occur in a longeron or in a fitting you are no better off than with a completely welded structure. Of course, the complete solution is to make the fittings entirely separate and bolt or rivet them to the longerons and struts, but this runs up the cost of construction even higher. Perhaps the answer is to use a welded structure and make the fittings the strongest part of the frame so that if failures occur they will take place at points other than the joints. If an aluminum alloy frame is used there is no alternative to the use of separate fittings at all joints.

Dependence of welding as a means of assembly has been looked upon askance by many designers because the personal skill and diligence of the welder is so important a factor in the quality of the finished product and because it is almost impossible to detect imperfect welds by visual inspection. The skeptics are gradually being silenced by the results which have been obtained in actual practice. There are hundreds of welded steel fuselages of many different designs in service and failures due to defective welds have been very few indeed. Ordinarily the weld is stronger than the tube itself and when failure does take place it is usually located just beyond the weld in the part of the member which has been softened by the heat of welding.

We come finally to the consideration of what is probably the determining force behind the urge for metal structures, that is the cost of production and the ability to produce in large quantities. It is risky to make broad statements regarding costs because there are so many factors which must be considered, such as labor charges, details of design, number of planes being constructed, past experience of the builder, etc., but it is generally considered that on a large production order a well designed welded steel fuselage can be constructed at less cost than any other type. With metal too there is no concern about a possible shortage of raw materials. Ash and spruce of the quality required for airplane construction are becoming stead-

(Continued on page 152)

WIRE automobile and airplane wires, electrical wires, submarine cables, bridge-building cables, wire rope, telegraph and telephone wire, radio wire, round wire, flat wire, star-shaped and all different kinds of shapes of wire, sheet wire, piano wire, pipe organ wire, wire hoops, barbed wire, woven wire fences, wire gates, wire fence posts, trolley wire and rail bonds, poultry netting, wire springs, concrete reinforcing wire mesh, nails, staples, tacks, spikes, bale ties, steel wire strips, wire-rope aerial tramways. Illustrated story of how steel and wire is made, also illustrated books describing uses of all the above wires sent free.

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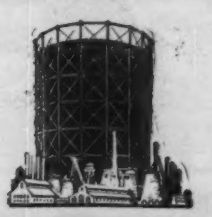

Aeronautical Research

(Continued from page 148)

is large. The maximum lift coefficient on thin sections remains generally about the same value; on medium thick sections, there is usually a tendency for this characteristic to increase as the scale is increased; however, on the very thick sections there is usually a decrease in the maximum lift varying with the amount of camber and the thickness. With the minimum drag coefficient, in all cases, a decrease occurs as the scale is increased, this is more noticeable at low values of Reynolds Number and is greater with the thicker sections, whose drag at low scale is relatively high. Generally the value of the minimum drag coefficient tends to approach a constant as the condition of a full scale airplane is approached.

Similarly, scale effect has been determined on several airships and airplane models. Here, also, there is a reduction in the minimum drag coefficient as the scale is increased.

Other tests have determined the effects of a flap or ailerons on the characteristics of an airfoil, the effect of reverse curvature on the travel of the center of pressure, the influence of the tunnel walls on the data obtained from tests, and the coefficient of surface friction; tests have also been made to determine the flow conditions of the tunnel itself, how the pressure and the velocity vary at different points in the cross section and particularly close to the tunnel wall.

From a great number of investigations, there have been obtained proofs of the principle on which the variable density wind tunnel operates. Full scale tests made on full sized machines bear this out as well. Hence, tests made in this wind tunnel may be used for design without the scale factor being an unknown factor.

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Airplane Power

(Continued from page 116)

itself well to air-cooling, it is quite possible that the air-cooled engine will be displaced by the water-cooled engine in the not far distant future.

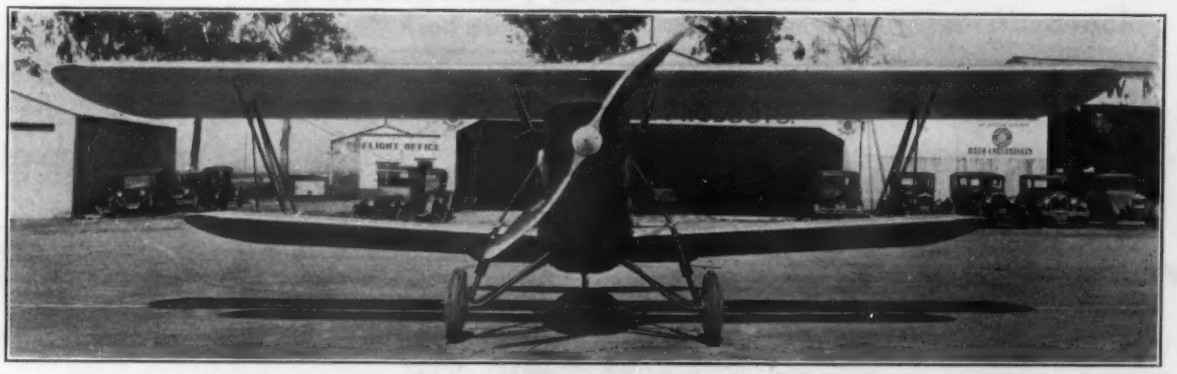
The interesting thing about this whole situation is the fact that it is in a state of flux and that no one type or style of engine is so firmly fixed that it is certain to hold its own indefinitely. At the present time, however, the high speed fuel injection engine is the only fundamentally new type which appears to have possibilities of being a dangerous competitor to the present types. The gas turbine and steam plant which have been spoken of in connection with aeronautical work, present problems which at the present time appear to be insurmountable, so that there is little danger of either of these being a serious competitor in the aeronautical field, at least in the near future.

Fuselage Construction

(Continued from page 150)

ily scarcer and more expensive and it will be recalled that strenuous efforts were made during the last war to obtain spruce for airplane stock.

In summing up the case of wooden vs. metal fuselages we may conclude that a welded steel fuselage offers better protection to personnel in a crash, but in the present state of our knowledge of corrosion prevention one may be a little uncertain as to its strength after some years of service. It is not quite as easy to repair but over a long period will probably require less expenditure for maintenance; it is cheaper and raw material is plentiful.



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Shortly thereafter, because of his special interest in the instrument field, he was dispatched on an engineering trip abroad, visiting and working in England, Norway, Sweden, Denmark, and France. Upon his return he entered commercial work and was assigned to the Pittsburgh territory—(including such industrial centers as Cleveland, Youngstown, Pittsburgh)—as specialist responsible for the sales, service, and operation of watthour meters, instruments, and relays in this important district. Here he will be found today, acting as intermediary between the sales force on the one hand and the engineering and factory departments on the other. He backs up the salesmen with a highly specialized knowledge. He advises with the engineers and with the factory in the design and manufacture of apparatus that is best suited to commercial requirements.

His own pioneering spirit has still found field for play, so that this year he demonstrated to the A.I.E.E. the first advance in the method of calibrating watthour meters in thirty years. Some 16,000,000 tests of watthour meters are made in this country annually. They cost about 20c apiece. Sparkes has devised a practicable method that chops more than 50% off this bill. It eliminates the human element; it gives greatly improved accuracy.

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Westinghouse

WESTINGHOUSE ELECTRIC

Departmental Notes

(Continued from page 148)

appreciation of all methods of power generation, the correct design of combustion equipment, and a knowledge of the commercial aspects of fuel utilization. Therefore the Institute work further includes such subjects as the Development and Use of Power, Furnace and Retort Design, and Public Utility Management and Finance. Other subjects such as Heat Measurements, Economic Geology of Fuels, Gas Engine Laboratory, Properties of Materials and a quantitative study of the flow of fluids and heat also form an important part of the work done at the Institute.

The practice of fuel engineering is strongly experimental in character, and investigations both on laboratory and plant scale are constantly necessary. Plant and laboratory research are therefore important features of the education of a fuel engineer. In the Course in Fuel and Gas Engineering the training in plant investigation is carried out at field stations which are located at the plants of the Bethlehem Steel Company and the Iroquois Gas Corporation, Buffalo, N. Y., Cambridge Gas Light Company, Cambridge, Mass., and the Bayonne Refinery of the Tide Water Oil Company.

The field work is carried on under the direct supervision of a member of the Institute faculty and is carefully planned to supplement and correlate the class room work done at the Institute. The field work is so organized that the student acquires training in the application of the principles of his profession and an intimate first hand knowledge of the methods of operation, equipment, and products of typical fuel processing and consuming industries. The field experimental work is done on full-size plant equipment in regular operation.

The type of field work is typified by investigations recently completed. At the Bayonne Refinery a comparison was made of the efficiencies of two crude oil stills, one fired with oil and the other with anthracite fines. At this same plant a test on a new battery of continuous crude stills capable of separating 25,000 barrels of crude petroleum per day into gasoline, kerosene, gas oil and fuel oil afforded opportunity to study not only the fuel efficiency of the unit but also methods of heat transfer and the distillation processes involved.

A thermal balance was made on a modern coal gas retort carbonizing 300 tons of coal per day, together with the auxiliary apparatus such as gas producers and waste heat boilers. This test provided both an opportunity to apply directly knowledge of coal carbonization acquired at the Institute and also training in the organization of large scale investigational work. Other field work of interest has included tests of boilers burning mixed fuels and a complete survey of heat distribution in a steel plant.

In addition to the investigational and test work carried out at the field stations a considerable amount of laboratory experimental work is being prosecuted in the Institute laboratories. Three of the most important investigations are, the study of organic liquids as boiler fluids, studies with reference to domestic heating, investigations dealing with the properties of flames and the transfer of heat from hot flue gases.

The problem of using organic liquids as boiler fluids is of considerable interest inasmuch as the use of these fluids has the possibility of greatly decreasing fuel consumption per kilowatt hour of electrical power produced. This process consists of generating under pressure the vapor of an organic material, the boiling point of which is far above that of water, extracting the work out of this vapor by expanding it through a turbine, condensing the exhausted organic vapor in a surface condenser in which steam in turn is generated at pressures around three to four hundred pounds per square inch through the heat of condensation of the organic vapor and then extracting power from this steam in the usual manner. Such a process if successful will permit the generation of power at efficiencies much above that of current standard practice.

The domestic heating field is assuming greater importance daily in view of the increased number of automatic gas, oil and coal heaters that are being installed. The advent of automatic heating in the home has made quantitative studies of house heating and its control desirable. Investigations are being carried out with different fuels and with various methods of automatic control.

Owing to the fundamental importance of the thermal and physical properties of flames, investigations are underway to determine the mechanism by which flames are propagated and this study is also being correlated with investigations on the transfer of heat from flames and from the hot products of combustion particularly by radiation from the hot gases themselves. The importance of this field may be appreciated from the fact that in certain types of oil cracking furnaces the heat transferred by radiation from hot gases may be equal to 20% to 80% of the heat transferred by conduction and convection. Until comparatively recently, this important factor has been almost wholly neglected.

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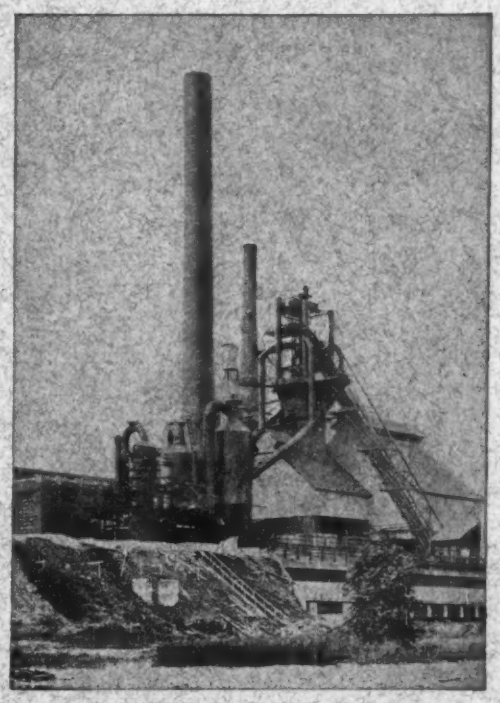

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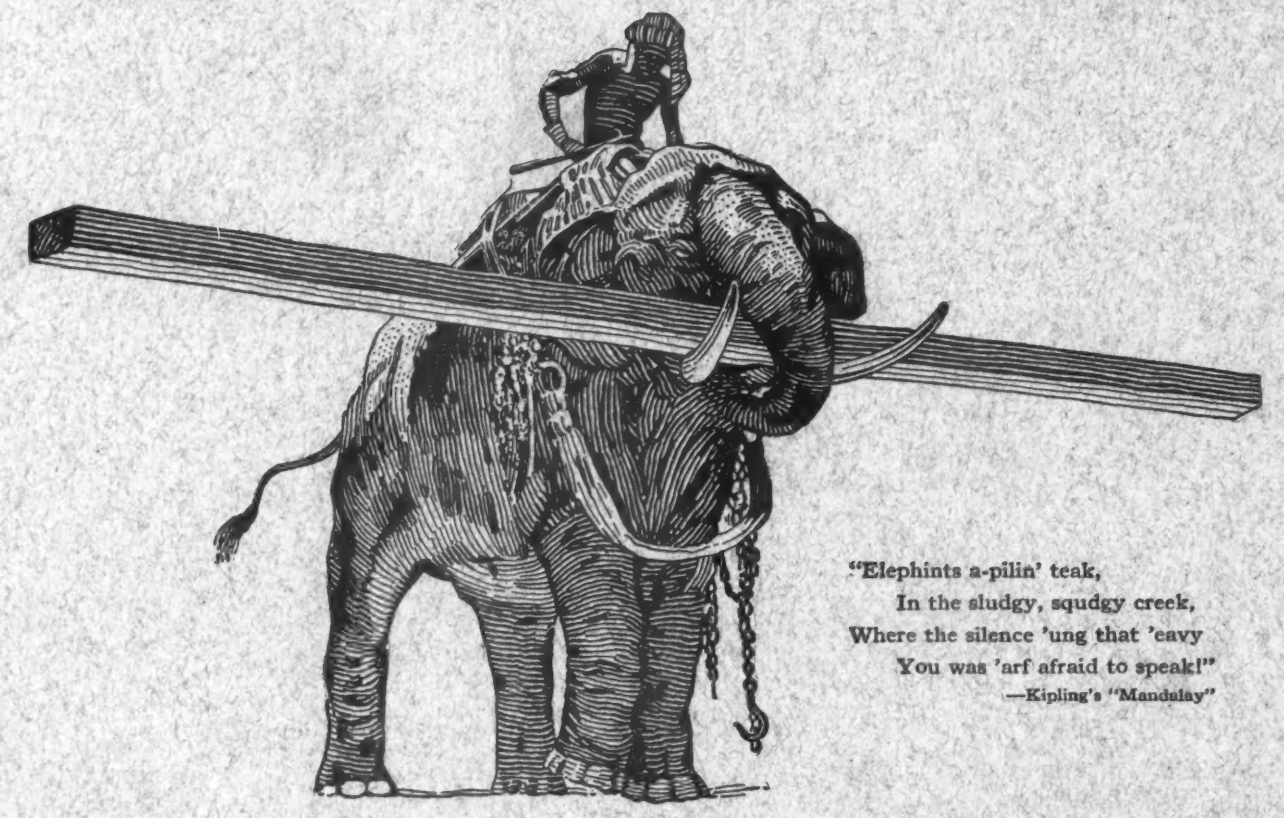

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Where the silence 'ung that 'eavy
You was 'arf afraid to speak!"
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